INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

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JULY 1959

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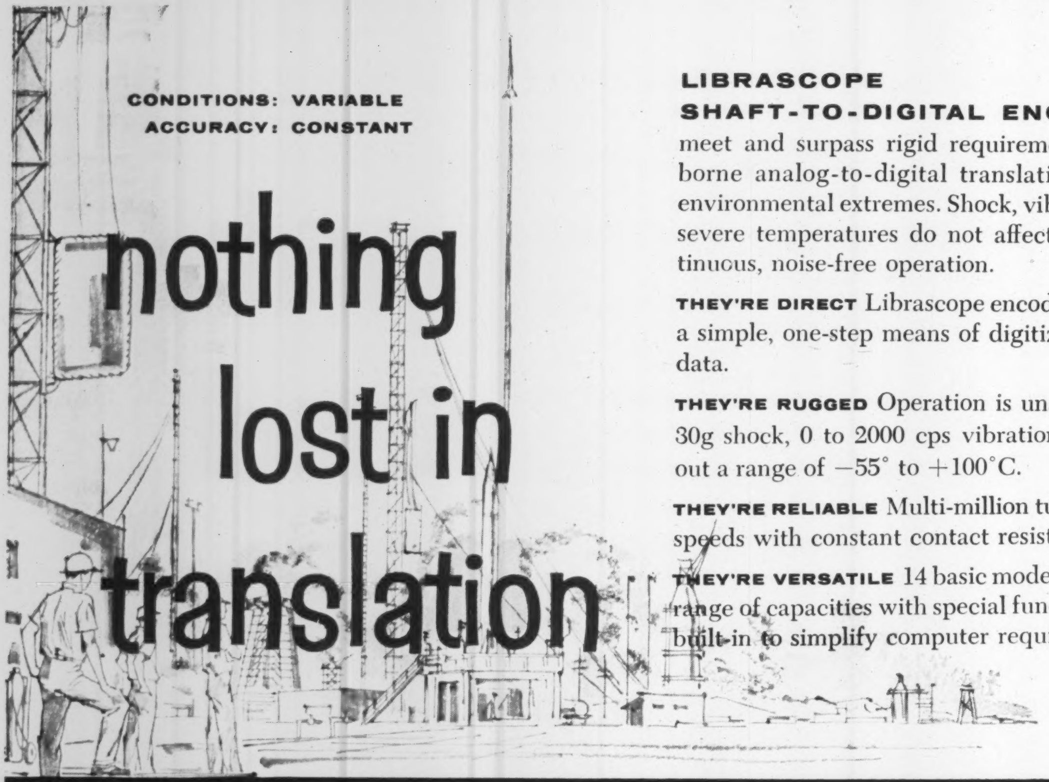
THIS PRINTING: 30,250



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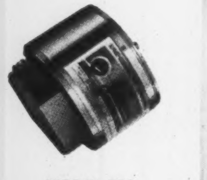
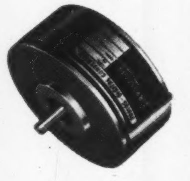

MODEL 758

MODEL 724


MODEL 708

OUTPUT CODE	MODEL NO. @	TOTAL CAPACITY	RESOLUTION PER TURN	DIMENSIONS DIA. x LENGTH
PARALLEL BINARY (LINEAR)	740	10 bits (1024)	1024	4 3/16″ x 2 1/4″
	743	13 bits (8192)	128	2″ x 3 15/32″
SERIAL BINARY (LINEAR)	707	7 bits (128)	128	2″ x 2 49/64″
	713	13 bits (8192)	128	2″ x 3 15/32″
	717	17 bits (131,072)	128	2″ x 4 13/16″
	719	19 bits (524,288)	128	2″ x 4 13/16″
SERIAL BINARY (SIN-COS)	757†	7 bits per quadrant* (4 quadrants)	512	2 1/4″ x 4 1/16″
	758†	8 bits per quadrant* (4 quadrants)	1024	4 1/8″ x 3 5/16″
BINARY CODED DECIMAL (8-4-2-1)	723	2,000	200	3 1/16″ x 4 27/32″
	724	20,000	200	3 1/16″ x 4 27/32″
	733	3,600	200	3 1/16″ x 4 27/32″
	734	36,000	200	3 1/16″ x 6 3/8″
	735	360,000	200	3 1/16″ x 6 3/8″
GRAY	708	8 bits (256)	256	3 1/16″ x 1 11/16″

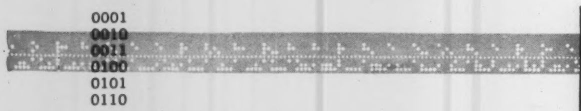
@All models available with internally mounted isolation diodes for sequential multiplexing applications.

†Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

*Including limit 1 and polarity information. Sine and cosine functions generated simultaneously and independently. One turn of shaft generates 4 quadrants of information.

For full details on Librascope shaft-to-digital encoders write for catalog E 11-1.

L19-1



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CIRCLE 1 ON READER-SERVICE CARD

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for
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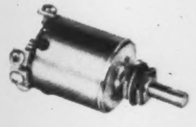
THERMOMETERS

THE 9S SERIES / *The Space Savers*

Small, sturdy, steel cased switches, 1¼ inches in diameter, 2⁹⁄₃₂ inches total shaft length, one-hole mounting with ½ inch-32 NS-2A threaded bushing. Designed especially for connecting two or more resistance bulbs to one instrument.

Part No.	Description
9S5	Single pole, four positions (with knob)
9S5B	Single pole, four positions
9S5E	Single pole, five positions
9S10	Double pole, double throw

All make before break, the instrument connected is never subjected to an open circuit during the switching operation.



1¼ INCH SIZE

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

		Switch Part Numbers	
Points	**Size**	**Thermocouple Type**	**3 Wire Resistance-Thermometer Type**
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2 INCH SIZE

3 INCH SIZE

SPECIAL SWITCHES

37S6C2, Four "4-point and OFF" thermocouple switches combined in one 3″ case.

The 44S Series, 2⁹⁄₃₂ inches in diameter, shaft 2¼ inches, approx. One-hole mounting with ½ inch-32 NS-2A threaded bushing.

Part No.	Description
44S4	Six pole, double throw
44S7B	Double pole, four position
44S7B2	Double pole, double throw

For use with resistance thermometer, contacts make before break.

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

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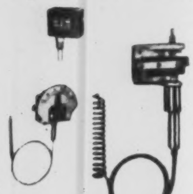

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MEDIUM: Air, liquid or hotplate.

RANGE: −150 to +650°F, adjustable.

SENSITIVITY: ±.5°F and up.

SWITCHES: Normally closed, open or double throw. Manual reset, high ambient and others available. 15 or 20 amps. 115/250 Volts AC. Also DC.

TYPES: Local mounted, remote bulb, skeleton or enclosed, calibrated or uncalibrated, single or multi-switch, indicating, explosion-proof, minimum size and special purpose.

OPERATION: Precision-made, liquid filled bellows combine with full rated snap-action switches for quick, accurate response to temperature change.

For further information request Condensed Catalog #400.

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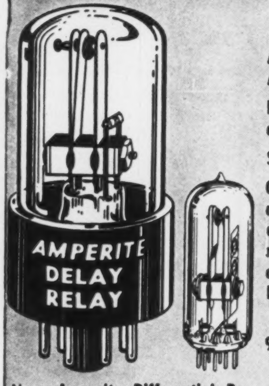
THERMOSTATIC

DELAY RELAYS



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Compensated for ambient temperature changes from —55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

TYPES: Standard Radio Octal, and 9-Pin Miniature . . List Price, $4.00. Standard Delays

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PROBLEM? Send for Bulletin No. TR-81

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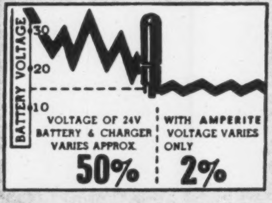

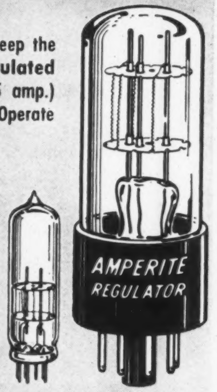

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REGULATORS—CIRCLE 5 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS

Formerly INSTRUMENTS and AUTOMATION

JULY 1959

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Control Via Capacitance Measurement, 1038

GEORGE REVESZ—capacitance effects can be used to measure moisture content, liquid or granular level, chemical composition and dimensional changes

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INSTRUMENTS
AND
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VOL. 32 No. 7 JULY, 1959

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AMF Model AD-500 Centrifuge

Control panel close-up showing CMC Model 620 Go-No-Go Gauge

How AMF uses CMC electronic counting equipment

For Motor Speed Control

American Machine & Foundry's Model AD-500 is a high speed centrifuge for environmental testing of electronic components. Capable of exerting acceleration forces up to 50,000 G's at 22,000 RPM, the completely automatic Model AD-500 requires a precise speed control system. The system must provide maximum user flexibility and simplicity of operation. AMF chose the CMC Model 620 Go-No-Go Gauge to give their Model AD-500 precise speed control within any pre-selected limits.

Basically, the CMC 620 is a dual preset counter with a built-in time base, which provides output information in the form of relay closures for control purposes. Before the Model AD-500 is started, upper and lower RPM limits are set on the control knobs of the dual preset decade units. The test is then begun. As the centrifuge rotates, a tachometer generator provides the input information to the Model 620 which reads directly in RPM. If the motor speed falls within the pre-selected limits, the green "IN LIMITS" lamp lights. Above or below limits, the red "HIGH" or "LOW" lamp lights and the associated relay closure takes place, de-energizing or re-energizing the motor to hold the centrifuge within pre-selected limits.

For complete specifications, description, price and applications information on the CMC Model 620, please address Dept.557.

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7

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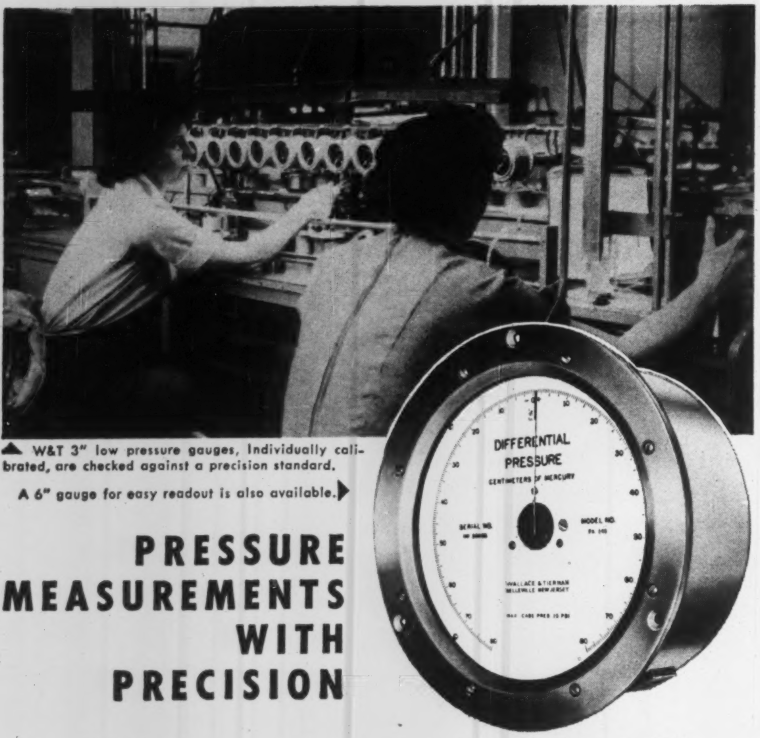

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to the editor

Editor, I&CS:

We are subscribers of *Instruments and Control Systems* and studying the technics of temperature measures making use of thermoelectric couples.

We have in our library the *Chemical Engineers Handbook* of John H. Perry 3rd and another book *Industrial Instrumentation* of Donald P. Eckman.

Consulting the Handbook of John Perry above referred, we have read, in page 1273, that the Chromel composition is 90% Ni 10% Cr.

Consulting the Industrial Instrumentation of Donald P. Eckman we have read in page 364 Table A-7 that the Chromel composition is 47% Fe, 32% Ni, 20% Cr.

We beg you to inform us about the right chemical composition of so important a metallic alloy, so that we may do a correct study of the thermoelectricity of the couples formed with that alloy and Alumel.

J. Lopez Ferro
Fabrica de Aparelhagem Industrial
Portugal

There are various compositions of both Chromel and Alumel on the market. Both Perry and Eckman, therefore, are right: Alloy 502, for instance, consists of 35% Ni, 18½% Cr, balance mainly Fe, etc. It seems that Chromel-P with approximately 90% Ni and 10% Cr is the alloy used in standard thermocouples. Alumel consists of 94% Ni with small amounts of Si, AL, and Mn. (Refer to *Condensed Chemical Dictionary*, Third Edition, Reinhold Publishing Corp.)

Inasmuch as both Chromel and Alumel are trade names of Hoskins Manufacturing Co., Lawton Ave. and Buchanan St., Detroit 8, Michigan, write to them or to the National Bureau of Standards, Washington 25, D. C., U.S.A.

Editor, I&CS:

I have devised a series of new mathematical functions in the field of applied analysis that would be of interest to your readers. The functions are based on transcendental "quasi-polynomials" arising from repeated indefinite integration of Cauchy's function $\exp [-(p/x)^2]$ together with mathematical constructions based on a series of terms of a type $\exp [-\cot^2 f\ (\theta, x)]$, etc.

With the aid of my new functions

it is possible to construct single mathematical expressions for entire curves hitherto not amenable to such treatment. Thus, I can represent the phenomena of magnetic saturation, electron flow, chemical and electrochemical yield, quality control, response to components of automation devices, etc., whose practical mathematical treatment at present is still rudimentary.

David Briansky, P. E.
Bronx, New York

Editor, I&CS:

I am performing a literature search on strain gages, the specific area of interest being:

1. High temperature strain techniques reported on in the last two years.
2. Techniques used to transmit strain signals from rotating machinery, e.g., slip rings, telemetering, etc.

I would appreciate a listing of any articles that might have been printed in your publications to augment a study by the Instrumentation Section of our Electronics Laboratory.

Richard Dineen
American Machine & Foundry Co.
Stamford, Conn.

Our recent series of strain-gage articles is available in the book *STRAIN-GAGE INSTRUMENTATION* ($2).

Editor, I&CS:

Considerable experience in in-plant teaching and consulting in the field of Statistical Quality Control has whetted my interest in the subject of instrument evaluation. I have been asked to give a paper on this subject at the Fourteenth Midwest Quality Control Conference in French Lick next fall.

Certain fallacies have in the field come to my attention.

a) Some engineers appear to neglect the need for evaluation completely.

b) Others assume that all error of test and observation lie in the instrument itself, and strive for super-refined precision and accuracy regardless of application.

c) Manufacturer's claims are so tight in many cases that they cannot be checked even in carefully controlled instrument laboratories, let alone on the job.

I have been checking through the literature to find how instrument evaluation is described, and to find standard terminology. This search has been disappointing. Behar's *Handbook of Measurement and Con-*

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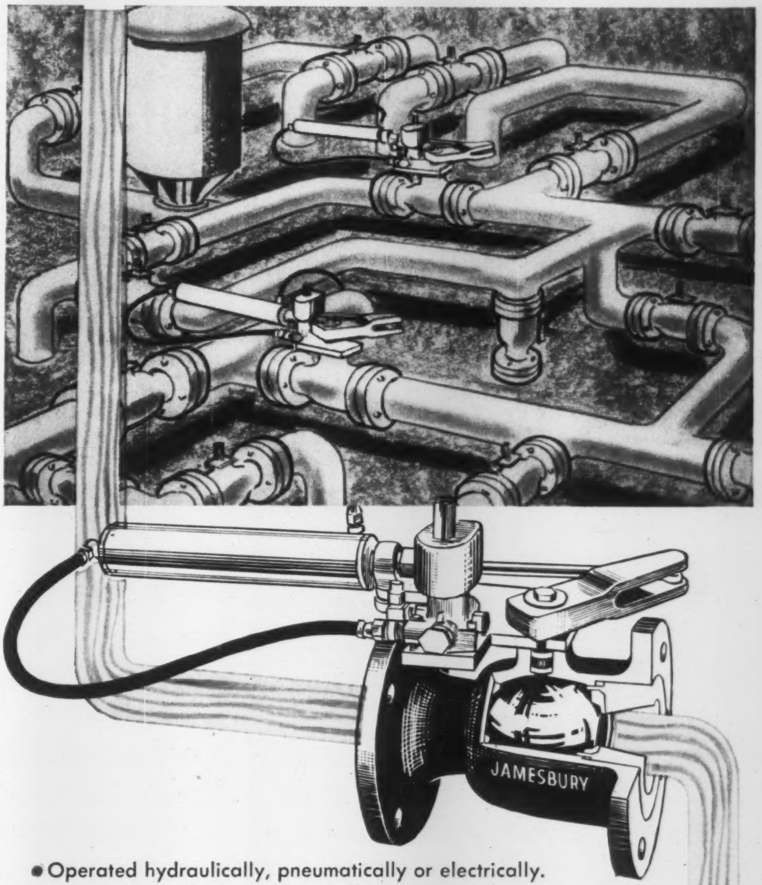

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trol is the most complete treatise thus far. I cannot seem to find anything put out by either the National Bureau of Standards or the American Standards Association.

The second part of the project, that of presenting statistical techniques for the evaluation of instruments and test personnel is not difficult. *Instruments and Control Systems* is to be congratulated on a fine series of articles on the subject. I have over thirty references already on the basis of a short search.

It is my hope that if some authorative reference is not already in existence, that steps can be taken in this direction. I have urged the American Society for Quality Control to open negotiations with other interested parties for a joint study on the subject. It seems to me that it could pay handsome dividends in reaching agreements on basic definitions and methods of evaluation, and provide means for checking or eliminating extravagant and ambiguous claims by manufacturers.

John A. Henry
Professor of Mechanical Engineering
University of Illinois
Urbana, Ill.

Editor, I&CS:

I belong to the Southern California Meter Association and receive a subscription to *Instruments and Control Systems.*

This magazine is one that I would not want to be without. I enjoy it very much.

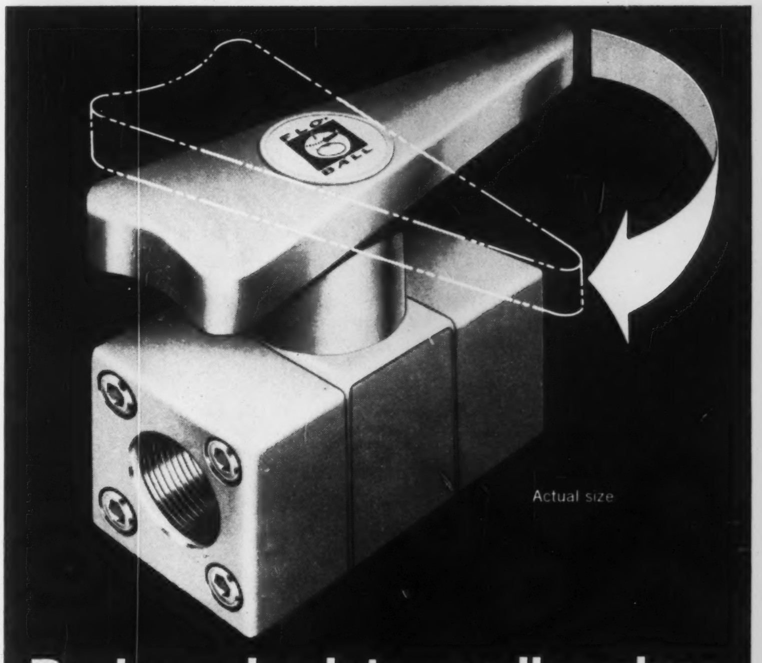
D. N. Harris
Yorba Linda, Calif.

Editor, I&CS:

Your readers might be interested in knowing about a breadboard scheme that Chuck Engle and I have developed. It consists of thumb tacking a schematic to a soft pine board. Thumb tacks are then placed at all circuit intersections and parts soldered between them directly over their symbolic representation on the schematic. It really is a time and THINK saver. I know of one company that consumes 40 dollars worth of thumb tacks in a month.

Everett J. Sadler
Digital Devices Co.
San Diego, Calif.

This thumb-tack idea is WONDERFUL. Thumb tacks would have to be used at each end of each component and at each corner. The rest is routine and fast. Each test point is a nice big tack head; the schematic is right there for voltages and waveforms.



Replace obsolete needle valves with the

NEW 90° ON-OFF

FLO·BALL

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru ***FLO·BALL*** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valve!

Versatile service . . . ideal for leak-proof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

SERIES 715

Port Styles and Sizes

NPT		AND10050	
Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

Write today for new catalog describing the world's most complete line of precision valves for industrial and military applications.

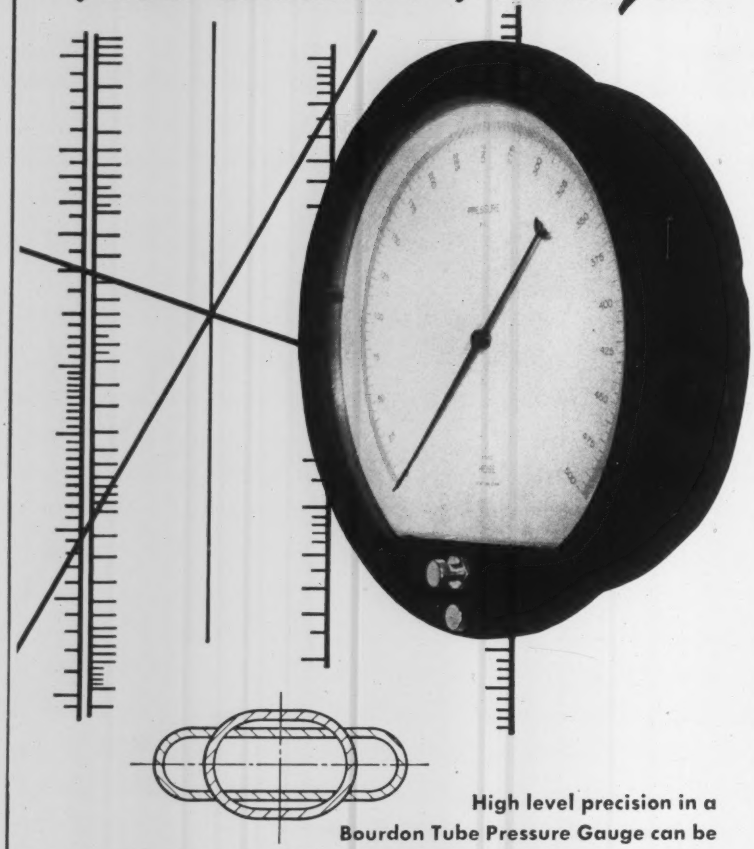
Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

CIRCLE 12 ON READER-SERVICE CARD

HEISE GAUGES

Tube Section Analysis



High level precision in a Bourdon Tube Pressure Gauge can be achieved only by scientific design of tube section and scrupulous selection of material.

The Bourdon Tube is a hollow, curved beam acted upon internally by fluid pressure in widely varying degree and affected, in some applications, by broad temperature ranges. Uniform distribution of displacement throughout the gauge range and precise control of induced stress requires individual analysis of each gauge application.

Using data and formulas developed by their own laboratory, Heise engineers specify a length-width ratio, wall thickness and all information for maximum performance in each application of their gauges.

Pressure Ranges 15 to 50,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $166.75 DELIVERY WITHIN 30 DAYS

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 13 ON READER-SERVICE CARD

Editor, I&CS:

In our search for historical electrical equipment we find very little in the way of instruments and I doubt if many are available.

Would you include the following notice in your publication, as it may bring some results:

Inventory Help Sought
on
Outdated Electrical Equipment

An inventory of outdated electrical equipment, especially electrical measuring instruments, is under way by the Electrical Historical Foundation. It is tabulating all equipment on display, in storage or still in use throughout the United States and Canada. Museums, Utilities, Educational Institutions and manufacturers are among the organizations from whom information is being solicited. Information on any old equipment, "the older, the better" may be addressed to the Foundation, Box 93, Newfane, Vt.

E. S. Lincoln
Electrical Historical Foundation
Newfane, Vt.

Editor, I&CS:

The Board of Directors of the Society of Technical Writers and Editors has asked me to pass along to you their thanks for the very fine talk which you gave us on March 19. You certainly managed to say a great many things that needed to be said, and an unusually large number of people spoke to me about what a fine program it was. All of us are very grateful for the time and effort you put into it.

At the Board meeting on Monday evening, the members endorsed Erwin Steinberg's suggestion that we submit your paper to the *STWE Review* with our recommendation that it be accepted for publication.

Many thanks again for your fine talk.

William M. Schutte
STWE
Carnegie Institute of Technology
Pittsburgh, Pa.

Editor, I&CS:

We thought you might be interested in knowing that your book *Strain Gage Instrumentation* was passed out as a reference manual at the recent sales seminar held by Baldwin-Lima-Hamilton for their national sales representatives. The book was recommended as a valuable aid to the sales engineers in familiarizing them with the problems and instrumentation currently available

A HOFFMAN SEMICONDUCTOR APPLICATION CASE HISTORY

THIS CONTROL PROBLEM HAD TO BE SOLVED

FOR AUTOMATIC DOLLAR BILL CHANGERS

DOLLAR BILL CHANGER

Hoffman Silicon Solar Cells were the solution

A.B.T.'s (division of Atwood Vacuum Machine Co., Rockford, Illinois) intricate control problem in their unique "bill changer" required Hoffman Silicon Solar Cells, of exacting quality, to automatically register the authenticity of a dollar bill, in this innovation in automatic vending.

You, too, may have a control problem requiring immediate and accurate registering—instantaneous response (20 microseconds)—long life (10,000 years*)—high light conversion efficiency (up to 10%)—wide spectral response range (4,000-11,500 angstroms)—extended operating temperature range (—65°C to +175°C).

Hoffman Silicon Solar Cells, born from the same family as those which are still powering the U. S. Navy's Vanguard satellite's radio transmitter, can be the answer to your control problem. For details consult the Hoffman Solar Cell applications specialist in your area or write to Department SS.

If you need a job in electronics done quicker and better, contact

Hoffman Electronics
CORPORATION
SEMICONDUCTOR DIVISION
930 PITNER AVENUE EVANSTON, ILLINOIS

---

*(Per R.C.A. Laboratories, Princeton, New Jersey, Report No. 212-PH-55-91 [1114], April 15, 1957)

CIRCLE 14 ON READER-SERVICE CARD

PERFECT
COMPANION
for your recording oscillograph
Type 23-109A

CEC's *new improved* **OSCILLOGRAM PROCESSOR**

It's a portable "darkroom" for on-the-spot processing of oscillograph records. Completely self-contained, motorized for automatic operation, and designed for daylight operation. Provides developed, dry, and ready-to-use oscillograms quickly. The Processor saves time and expense by permitting prompt checks of recorded data to determine results *fast*. This often eliminates necessity of additional tests. The Processor is ideal for field use; no external water supply is needed.

The 23-109A features variable bath temperature control to accommodate future chemical processes . . . Variable drum-temperature with *thermistor* sensing element eliminates troublesome open thermostats . . . Adjustable magazine accepts record widths to 12 inches . . . New design permits side-by-side processing of two narrow rolls . . . Simplified threading allows anyone to process records perfectly every time.

Spare magazines are available for rapid sequence work. Ready-mixed chemicals are packaged for complete filling of processor tanks. Available for 115-or 230-volt, a-c operation.

For complete information, call your nearest CEC sales and service office or write for Bulletin CEC 1537-X2.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS

360 Sierra Madre Villa, Pasadena, California

CIRCLE 15 ON READER-SERVICE CARD

LETTERS—CONTINUED

in the field of strain gage measurements.

At another sales seminar which was held by Sensitive Research Instrument Corporation copies of two articles which appeared in *Instruments and Control Systems*, January 1959 issue, were passed and recommended as sales aids for the equipment which they manufacture.

We would like to congratulate you on the fine job Instruments Publishing Company is doing in distributing this type of information to our industry.

Herb Moulds,
Sls. Engineer
S. Sterling Company
Pittsburgh, Penna.

reader inquiries

Pinhole Detector

Manufacturer of auto products seeks detector of pin holes in electric-welded steel tubing from 1½" to 2½" O.D. with wall thickness from 0.030" to 0.042". A-410

Ultrasonic Scale Cleaner

Head of instrumentation department of Canadian mine seeks ultrasonic device which could loosen scale in heat exchanger with subsequent flushing by normal flow. A-411

Hook Gage, Smoke Generator

Canadian manufacturer of precision instruments seeks (1) Pendergast Hook Gage for water from 0 to 12#, and accuracy of ±0.001", and (2) smoke generator or bomb with approximately 5-min operation time. A-412

Electropneumatic Converter

Head of College mechanical engineering dept. seeks "unit to convert millivolts (thermocouple measurements) to pressure output with a range of 3 to 15 psi." A-413

Small Hair and Wire Brushes

Asssistant chemist of State Department of Agriculture seeks small brushes (½ mm dia) made of hair or wire. A-414

Frequency-Selective Relays

Consulting engineer in Sweden seeks frequency-selective relays. A-415

Firestone Plastometer

Head of instrument department seeks manufacturer of "Firestone Plastometer." A-416

NC NORWOOD CONTROLS

PRESSURE TRANSDUCERS

BONDED STRAIN GAGE RUGGEDNESS

No damage at 1,000 g to 2,000 cps . . . no unsupported fine wires to resonate or fracture.

2 in 1 — *BOTH* static *AND* dynamic measurements with *ONE* transducer . . . for use with any read-out equipment from standard strip-chart recorders to cathode ray oscilloscopes.

PLUS — 4 arm 350 ohm strain gage bridge . . . high dynamic response: natural frequency 50 KC; damping constant .2 (cooled) . . . only 1/4 of 1% maximum zero shift when flame of acetylene torch passes rapidly over diaphragm . . . all welded diaphragm for corrosive applications . . . ranges: 0-25 to 0-60,000 psi.

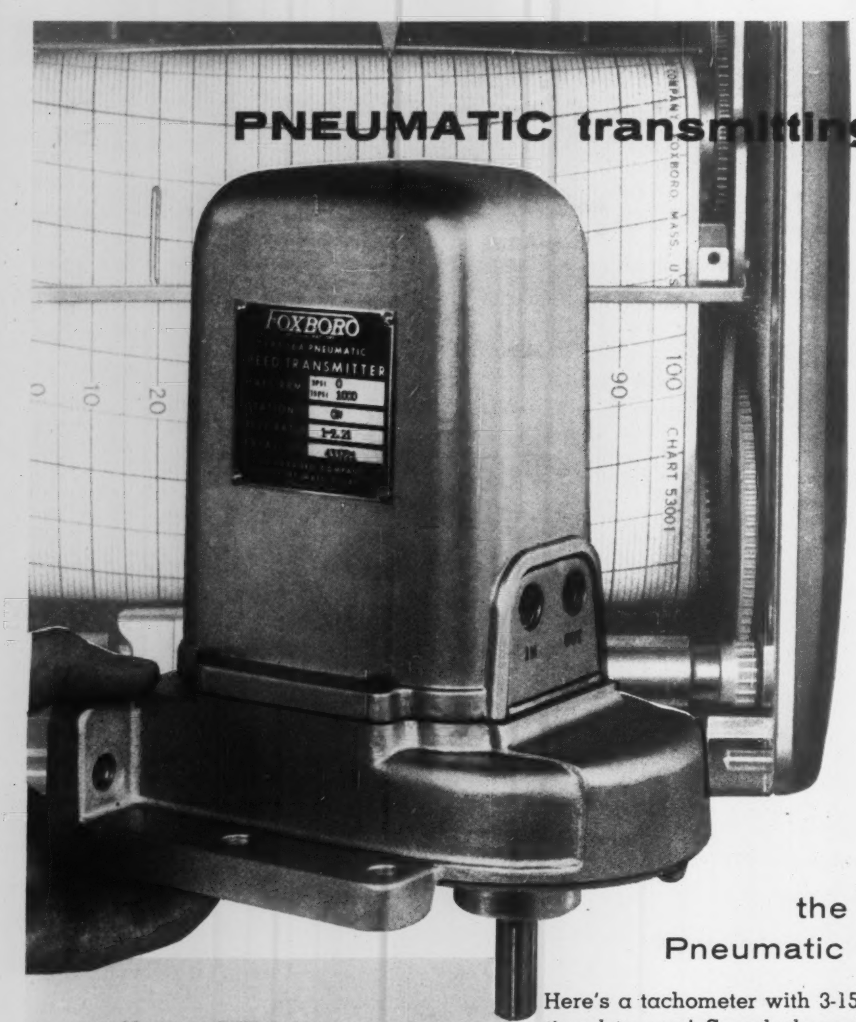
WRITE *for data sheets covering Norwood Controls Transducers, Norwood Controls Unit, Detroit Controls Division,* **937** *Washington Street, Norwood, Massachusetts.*

AMERICAN-Standard
DETROIT CONTROLS DIVISION

CIRCLE 16 ON READER-SERVICE CARD

PNEUMATIC transmitting tachometer with

DIRECT LINEAR SIGNAL



the Foxboro Type 16A Pneumatic Speed Transmitter

- **Mounts in ANY position**
- **Accurate to ±½% across entire range**
- **Needs no lubrication**
- **Dust-tight gasketed case continuously purged**
- **Simple force-balance mechanical principle.**

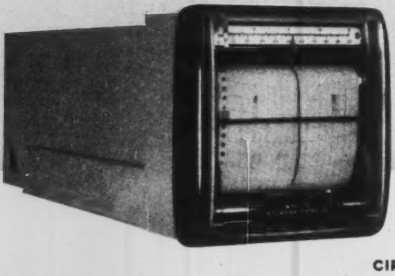
Here's a tachometer with 3-15 psi air signal *directly proportional* to rpm! Speed changes are recorded on a uniform-scale chart. Accurate measurements of rpm are easy to read throughout the entire range. No crowded bottom scale!

The Type 16A Speed Transmitter will measure *any* desired range. (An optional integral speed changer is available for ranges from 0-600 rpm to 0-6500 rpm). Full-scale accuracy of ±½% is consistently maintained. Small and light weight, it can be mounted *in any position* — never needs lubrication.

For rotating equipment having wide speed variations, the Type 16A is ideal. It's available for either clockwise or counter-clockwise rotation, and can easily be incorporated into any present pneumatic control system. Write for full details. **The Foxboro Company, 467 Neponset Ave., Foxboro, Massachusetts, U.S.A.**

Direct-connects to remote pneumatic recorder or controller, such as Consotrol* panel recorder shown below.

****Reg. U.S. Pat. Off.***



FOXBORO

REG. U. S. PAT. OFF.

PNEUMATIC SPEED TRANSMITTERS

CIRCLE 17 ON READER-SERVICE CARD

trends

Commercial Discount Corp. is creating a new division to purchase industry receivables (accounts receivable) in 10 Midwest industries because manufacturers, being paid slowly by their customers, need financing. The industries include electronics and scientific instruments.

BDSA, Dept. of Commerce reports on production of electrical instrument Mechanisms for fiscal 1957 as follows:

Permanent Magnet—Moveable Coil	1,983,222
Double Coil and Double Winding	36,837
Moveable Iron	346,467
Electrodynamometer	24,210
Instrument Relays and Contact Making	99,957
Direct Deflecting Recording-Controlling	99,050
Self-Balancing Indicating Recording-Controlling	52,037
Miscellaneous A. C.	6,938
Other Instrument Mechanisms, included in Multi-Purpose and Composite Instruments	335,297
	2,983,915

Thirteen universities have asked NSF for $71 million to establish a National Institute for Atmospheric Research. This will expand weather, pollution, and atmospheric instrumentation markets.

Russian astronomical research lags West's says W. Liller of U. of Mich—but development rate is faster because of larger number of astronomers and plentiful supply of smaller instruments for training them.

Contrary to all predictions, enrollment in freshman engineering in colleges and universities is falling—is now 11.1% below 1957; 10% below 1958. However, enrollment in basic physical sciences is up slightly. One reason for low motivation appeal of engineering—inadequate instrumentation at all levels of teaching, particularly critical secondary-school level.

The trend toward mergers is again increasing in the instrumentation and control industry, the result of present tax policies and the low cash position of most companies due to slow collections. The instrument industry is especially susceptible to mergers as companies were originally started by an individual and, due to rapid expansion, retirement is only possible through a merger or direct sales.

Joint council on Education TV reports that 133 closed-circuit education TV systems are in use by 119 organizations including schools, hospitals, etc. Those used by school systems include about 500 schools, and reach between 60,000 and 75,000 students. Open-circuit (on-the-air) TV instruction now reaches between 8000 and 10,000 schools and 10 million (about 25% of all) students.

In 1955, national income was spilt up as follows: manufacturing 31%; trade 17%; government 12%; services 9%; finance 9%; other (agriculture, construction, transportation, utilities and mining) 22%.

news

Electrical Indicating Instrument Manufacturers Organize NEMA Section

NEW YORK, N. Y.—Nine prominent manufacturers of electrical indicating instruments—panel, switchboard, and portable—have affiliated with the National Electrical Manufacturers Association as a new NEMA industry Section. *W. H. Steinkamp*, vice president of Daystrom, Incorporated, Western Instruments Div., has been elected chairman of the new Section, and *J. R. Whiteside*, president of Simpson Electric Co., has been named vice chairman.

As one of the first activities, the Section has named a Technical Committee, which is expected to work with Sectional Committee C-39 of the American Standards Association in developing new American standards for electrical indicating instruments. Committee chairmen are: Membership—*J. R. Whiteside*, president, Simpson Electric Co.; Statistics—*J. M. Heggy*, sales manager, Instrument Dept., Meter Div., Westinghouse Electric Corp.; Technical—*M. S. Wilson*, Manager—Electrical Instrument Engineering, Instrument Dept., General Electric Co.; Government Liaison—*W. R. Triplett*, president, The Triplett Electrical Instrument Co.; Trade Shows—*E. S. Maury*, Minneapolis-Honeywell Regulator Co.; Program—*J. F. Degen*, vice president, Operations, Daystrom, Inc., Weston Instruments Div.

Fifth International Automation Exposition Postponed

PITTSBURGH—Management for the Fifth International Automation Congress and Exposition has announced postponement of the show scheduled for the New York Trade Show Building, November 16 to 20, 1959. The show will be rescheduled for 1961.

Fluid Controls Institute Holds Spring Meeting

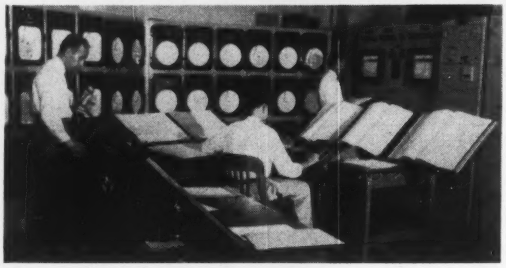
TUCKER'S TOWN, BERMUDA.—The Mid-Ocean Club in this island resort was the scene of the Fluid Controls Institute's semi-annual meeting, May 3, 4 and 5, 1959.

Sixty-seven members, wives, and guests, representing prominent manufacturers of control valves, regulators, solenoid valves, and steam-heating accessories, assembled here to hear reports on the business activities of the Institute, participate in a panel discussion on "Marketing Management," to be addressed by Professor Hector Laso of New York University on the subject of "Marketing," enjoy social activities and elect the following new officers for the coming year: President *James Lawler, Jr.*, Lawler Automatic Controls, Inc.; First Vice President—*Fred Weldon*, General Controls Co.; Second Vice President—*Robert McCormick*, Automatic Switch Co.; Treasurer—*Paul Rogers, Jr.*, Skinner Chuck Co.; Corporate Secretary—*Eric Bianchi*, Mason-Neilan Div. Worthington Corp.; and Executive Secretary—*E. R. Rath*, Fluid Controls Institute, Inc.

Colorado Utility Plans Computerized Gas Dispatching

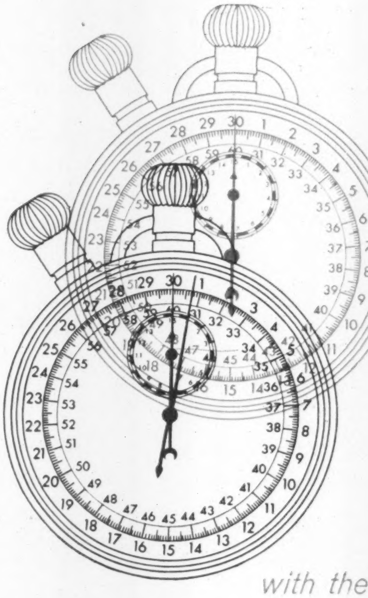
DENVER, COLO.—The first computerized system for on-line gas dispatching control will be installed in the Dispatching Division of Public Service Co. of Colorado.

The utility company is charged for gas on the basis of a commodity charge and its demand peaks taken from the highest 24-hour usage during the year. Involved in evaluation of the demand is the necessity for recording differential pressure, static pressure, temperature, and specific gravity values at some 15 metering stations. The existing system requires monitoring of 44 telemeters. To obtain preferential rates, industrial customers must agree to curtail use if the demand to the area approaches the condition of exceeding the pre-established peak usage.



The new Libratrol-500 system, manufactured by Librascope, Inc., will receive its flow data from the same circular-chart Bristol recorders from which the Dispatcher presently reads the flow parameter values. Each pen recorder will be fitted with a re-transmitting potentiometer, providing static pressure, differential pressure, and temperature data, which will generate an output voltage proportional to the value of the flow parameter being monitored by the recorder. Basic to the calculation of the flow is the orifice factor which defines the relationship between the pressure measurements and the flow on the basis of the characteristics of the gas, the flow meter, and the flow itself. The computer will be programmed to determine the value of this factor in accordance with the Gas Measurement Committee Report No.3 of the American Gas Association.

Outputs from the computer may be in the form of voltages to actuate control elements, digital data for presentation to operating personnel, or punched tape for further data processing operations.



INSTANTLY...

measure and supply DC voltages to 0.02%

with the new KIN TEL DC voltage standard and null voltmeter

LABORATORY ACCURACY. The Model 301 is an extremely compact and accurate variable DC power supply and calibrated null voltmeter. It employs KIN TEL's proved chopper circuit to constantly compare the output voltage against an internal standard cell. As a DC voltage standard, it combines the stability and accuracy of the standard cell with the current capabilities and excellent dynamic characteristics of the finest electronically regulated power supplies. The self-contained null voltmeter indicates the voltage difference between the supply in the 301 and the DC source being measured, affording simple and rapid measurement of DC voltages to an accuracy of 0.02%.

PRODUCTION LINE SPEED. DC voltage measurements can be made as fast as changing ranges on a VTVM. Merely set the direct reading calibrated dials on the 301 to exactly null out the unknown DC input voltage. The reading on the dials then indicates the value of the unknown input voltage to within 0.02%. As a variable DC standard or power supply, the calibrated dials provide instant voltage selection to an accuracy normally attained only with standard cells.

VERSATILITY. The KIN TEL Model 301 is ideal for rapid and accurate production calibration of precision measuring instruments and DC power supplies . . . design of DC amplifiers and complex electronic circuitry . . . computer reference . . . versatile precision reference for calibration and measurement laboratories.

0.01% stability
0.02% accuracy
1 to 501 volts at 20 ma
4 accurate null ranges
0.002% regulation
Less than 100 µv ripple

IMPORTANT SPECIFICATIONS

Output Voltage & Current	1 to 501 volts at up to 20 ma
Full Scale Meter Ranges (Zero Center)	
DC Output Range	±500, 50 volts
DC Input Range	±500, 50 volts
DC Null Meter Range	±50, 5, 0.5, 0.05 volts
Long Time Stability	±100 parts per million
Output Voltage Calibration	±0.02% or 2 mv
Output Hum and Noise	Less than 100 µv RMS
Line and Load Regulation	0.002%
DC Output Impedance	Less than 0.01 ohm
Response Time	0.2 millisecond
Model 301 or Model 301R (Rack Mount)	Price $795.

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

KINTEL
A DIVISION OF
COHU
ELECTRONICS, INC.

5725 Kearny Villa Road, San Diego 11, Calif., Phone: BRowning 7-6700

CIRCLE 18 ON READER-SERVICE CARD

the highest,
the coldest,
the hottest
. . . IN THE SMALLEST SPACE!

Tenney-mite STRAT
environmental chamber

Altitudes to 200,000 ft., temperatures from –100° F to +350° F, in only 4 square feet of floor space. Now, any company can own a combined altitude and temperature test chamber . . . without sacrificing much valuable floor space. And the investment, too, is reasonable.

Only Tenney Engineering, world's largest and most experienced creator of environmental equipment, could produce the Tenney-mite Strat. Write for further information.

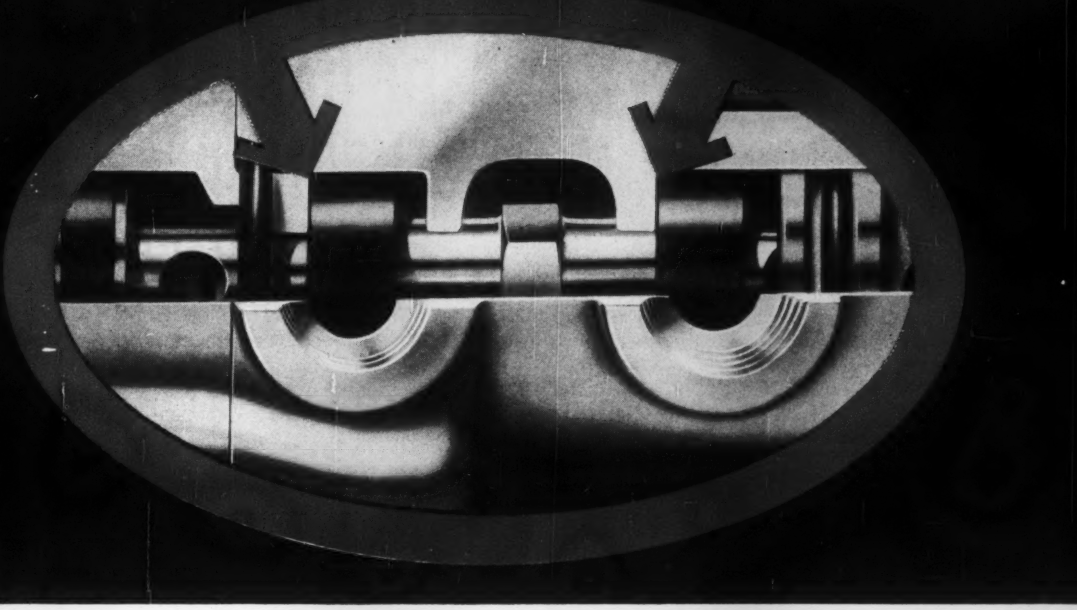
Write for a descriptive catalog and complete information on Tenney's research and development, engineering consultation, and design services.

Tenney
ENGINEERING, INC.
OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

1090 SPRINGFIELD ROAD, UNION, NEW JERSEY • PLANTS: UNION, NEW JERSEY AND BALTIMORE, MARYLAND

CIRCLE 19 ON READER-SERVICE CARD

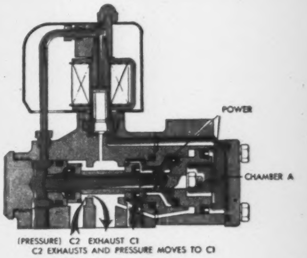
ABSOLUTELY TIGHT SEATING!



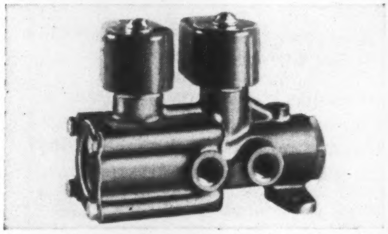
WITH ASCO POPPET TYPE 4-WAY SOLENOID VALVES

Dead tight shut-off—even on air—is assured in these four-way valves through poppet seals, and by a unique combination of metal to metal and resilient seating. No lapping, grinding or close adjustments are necessary—no binding or leaking can occur. Short piston disc assembly travel, basic design simplicity eliminate maintenance problems.

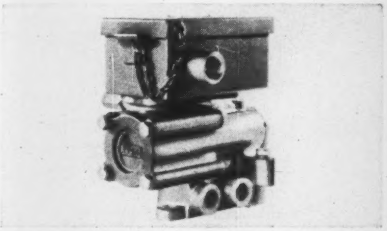
ASCO 4-way Valves are available in 3/8″ through 1″ sizes, in standard, explosion-proof or water tight enclosures. They can be mounted in any position, and permit cycling rates to 850 per minute.



Operation: ASCO Single Solenoid 4-way Valves are power-driven in both directions by line pressure. When the solenoid is de-energized, line pressure applied to the top of the piston core forces it off the seat, eliminating possible sticking due to residual magnetism. Line pressure is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and line pressure drives the piston to the right. Single solenoid type (illustrated) operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid (Bulletin 8344): operates when either solenoid is energized; will not return until opposite solenoid is energized (single solenoid types return when de-energized). In dual solenoid valves, solenoids may be energized continuously or momentarily.



J.I.C. Construction (Bulletin 8346) ASCO Single and Dual Solenoid Valves can be furnished to Joint Industry Conference requirements—valves are provided with subplates, vapor-proof solenoid enclosures, and manual overrides, and are electrically inoperative with the cover removed.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery . . . World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

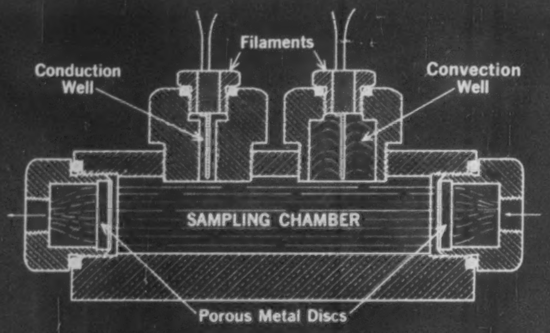
ASCO®

Automatic Switch Co.

52-F Hanover Road, Florham Park, New Jersey • FRontier 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 20 ON READER-SERVICE CARD



Cross Section of M-S-A Thermatron Type M Cell

Type M cell adds advantages of thermal convection to standard conductivity for selective analysis of one gas in a complex mixture of gases without scrubbing out interfering components.

THERMATRON

Non-explosion-proof type

THERMATRON
M-S-A
THERMATRON

Explosion-proof type

SOMETHING NEW IN ANALYSIS OF GASES BY THEIR THERMAL PROPERTIES

This unique development in gas analysis instrumentation combines thermal convection and thermal conductivity effects to provide selective measurement of a single component of a mixture without "scrubbing out" interfering components.

M-S-A® Thermatron* Gas Analyzer solves these and many other process problems

Process Control

Analysis—65-80% H_2
Background—0-1% HC, 14-20% N_2, 0-5% NH_3

Analysis—50-100% H_2
Background—26-27% CO, 0-½% HC + N_2

Analysis—80-100% H_2
Balance C_1 through C_5 Hydrocarbons

Analysis—0-15% Ethylene Oxide
Background—0-100% CO_2, 0-100% Air

Gas Purity

Analysis—95-100% CO_2
Impurities—0-4% H_2, 0-1% N_2

Analysis—97-100% H_2
Background—10-17% CO_2, 82-83% N_2 + HC

Atmosphere Control

Analysis—0-4% H_2
Background—10-17% CO_2, 82-83% N_2 + HC

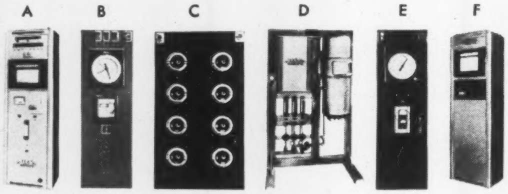
Combustion Control

Analysis—CO_2 or H_2
Background—H_2, CO_2, CO, N_2, O_2, HC

Purging Operations

Analysis—H_2
Change—100% H_2 to 100% CO to 100% Air
to 100% CO_2 to 100% H_2

MSA has solved these gas analysis problems and a multitude of others for over thirty years. Write us for new M-S-A Thermatron Gas Analyzer bulletin. Or for answers to specific gas analysis problems.



A—M-S-A® LIRA® Infrared Analyzer. B—M-S-A® Inert Gas Analyzer. C—M-S-A® Combustible Gas Analyzer. D—M-S-A® Water Vapor Recorder. E—M-S-A® Oxygen Indicator. F—M-S-A® Billion-Aire* Analyzer.

*Trademark

INSTRUMENT DIVISION
MINE SAFETY APPLIANCES COMPANY
Pittsburgh 8, Pennsylvania
MSA*

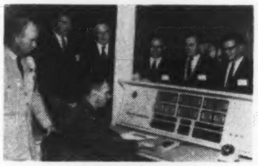
CIRCLE 21 ON READER-SERVICE CARD

NEWS—CONTINUED

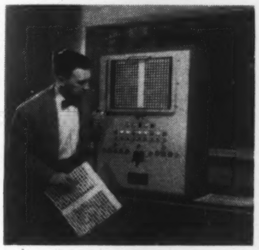
HAGAN CHEMICALS & CONTROLS has installed automatic combustion controls on twelve 200-ton soaking pits at Lukens Steel Co., among the largest ever built.

LEEDS & NORTHRUP has received an approximately $160,000 contract from Public Service Electric and Gas Co. of New Jersey, covering a data handling system for the two units at Mercer Generating Station near Trenton.

HOFFMAN LABORATORIES DIV., heading a team of seven companies cooperating in the "Tall Tom" electronic reconnaissance system for the Aerial Reconnaissance Lab of the U. S. Air Force, recently dedicated at Sanford Research Institute a Datatron 220 data processing system, purchased from Burroughs.



Burrough's Datatron 220



Bell Labs' SPUD

BELL LABS has added to its training program a Stored Program Universal Demonstrator (SPUD) to help new members of the staff and telephone company engineers understand the workings of digital computers and electronic telephone switching systems.

BRANSON ULTRASONIC CORP.'s cleaning equipment is used by Union Electric Co., St. Louis, on its instrument movements, relay parts, watches, threaded line jumper connectors, etc.

LIBRASCOPE has adopted a progressive or sequential quality control inspection system of printed wiring boards, a procedure which has speeded output and increased reliability of digital computers and other electronic equipment.

BRIDGEPORT THERMOSTAT Div. of Robertshaw-Fulton Controls is using an analytical mass spectrometer to test thermostatic control devices for gas leakage. Gases used for filling media include methyl chloride, sulphur dioxide, butane, freon, and helium.

AMERICAN STANDARDS ASSOCIATION has just published the new instrument ball bearing standard which was completed in summer 1958 by ASA Sectional Committee B3, Ball and Roller Bearings.

AMERICAN ELECTRONICS' subsidiary Taller & Cooper has designed and built an Automatic Toll Collector for the 1150-car Rego Park Municipal Parking Field in New York. By tossing 35 cents into a basket, electromechanical controls, counters, and computers are set in motion which open the gate, record the amount and the total for the day, and compute availability of space. They refuse to open the gate if there is no space or the proper coins have not been deposited.

GENERAL ELECTRIC has established an new D-C Advanced Engineering Center in Collingdale near Philadelphia which will explore new designs in equipment and components for the conversion of electric power by static means.

The Fifth International Automation Exposition and Congress

scheduled for the

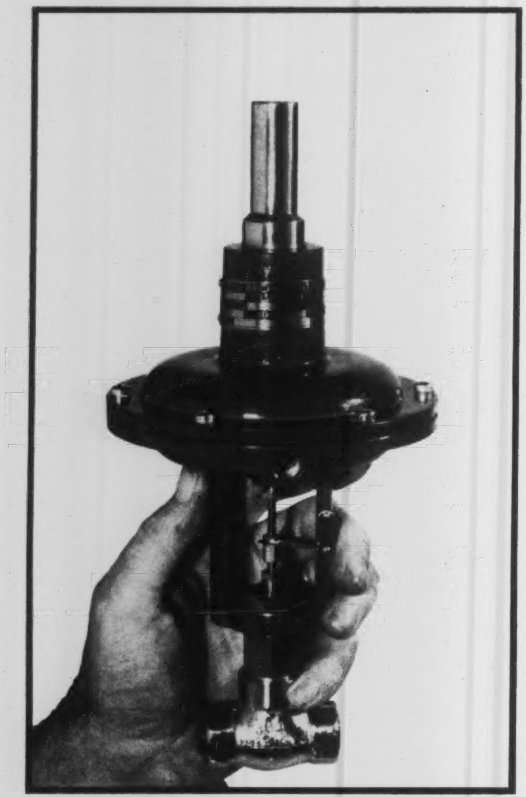
New York Trade Show Bldg.

NOVEMBER 16 TO 20, 1959

HAS BEEN POSTPONED

IT HAS BEEN RESCHEDULED TO 1961

MINIATURE DIAPHRAGM
MOTOR VALVES



MATERIALS OF CONSTRUCTION

BODY: Steel, 304 S/S, 316 S/S, Bronze, Monel, Hastelloy B or C OR ANY MACHINEABLE MATERIAL
PACKING: Teflon, Braided or Molded
TRIM: 300 SER. Stainless Steel, Monel, Hastelloy B or C
TOPWORKS: Cast aluminum with neoprene diaphragm

INNER VALVES

Quick opening — any size, Linear — all sizes
Equal percentage — C_v 0.05 and larger

CONNECTIONS

Screwed NPT 1/4" and 1/2", FLANGED, WELDED, ETC.

C_v VALUES

SIZE	Cv's AVAILABLE
1/2"	3.0 DOWN TO 0.05
1/4"	0.32 DOWN TO 0.0001

RESEARCH CONTROLS
INCORPORATED

P. O. BOX 5035 TULSA, OKLAHOMA
CIRCLE 23 ON READER-SERVICE CARD

stock report

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

AMERICAN STOCK EXCHANGE
PRICE RANGE 1959 THRU June 16, 1959

	HIGH	LOW	PRICE AS OF 6/16/59
American Meter	45 1/4	38	43
Aro Equipment	29 3/4	22	24
Barry Controls "B"	26	13 3/4	17
Belock Instruments	22 7/8	10	18
Benrus Watch	9	5 7/8	7 1/8
Breeze Corp.	9 3/8	6 1/4	6 7/8
Clark Controller	29 3/4	19 5/8	25 5/8
Clarostat Mfg.	10 1/4	4	7 3/8
Clary Corp.	10 7/8	5 3/4	8 3/8
DuMont Laboratories	9 7/8	6	8
Dynamics Corp. of America	12 3/4	4 5/8	9 7/8
Electronics Corp. of America	16 7/8	9 1/2	11 5/8
El-Tronics	2 1/4	1	1 1/8
Fairchild Camera & Instrument	138 7/8	50 3/4	130
General Transistor	88 1/4	49	69 7/8
Globe-Union	27 1/2	20 1/4	27 1/2
Hazeltine Corp.	75	54 1/2	62
International Resistance	22 3/4	7	17 5/8
Lear Inc.	19 1/4	9 1/8	14
National Research	39 1/2	15 3/8	26 5/8
New Haven Clock	5 3/8	1 1/2	3 1/2
Nuclear Corp. of America	4 1/4	1 3/4	2 3/8
Philips Electronics, Inc.	48 3/4	23 1/2	40 3/8
Pneumatic Scale	67	32	47 3/4-49 3/4 (1)
Servo Corp. of America	43 1/2	14 5/8	26 3/4
Servomechanisms	18 1/4	9	14 1/2
Statham Instruments Inc.	43	23	24 3/4
Victoreen Instrument Co.	19 7/8	6 7/8	13 1/2
Wallace & Tiernan	49 3/4	36 1/4	46 5/8
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 3/4

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1) Not traded - Bid and Asked

NEW YORK STOCK EXCHANGE
PRICE RANGE FOR 1959 THRU June 16, 1959

	HIGH	LOW	PRICE AS OF 6/16/59
ACF Industries	56 1/4	47 5/8	49 5/8
Aeroquip Corp.	33 7/8	23 5/8	29
Allis Chalmers	32 3/4	26 7/8	30 3/4
American Chain & Cable	61	47 3/4	55 7/8-55 (1)
American Machine & Foundry	89 1/2	53 1/2	82
American Machine & Metals	59 3/4	41	53 1/4
American Optical	49 1/2	38 3/8	45 7/8
American Tel. & Tel.	89	75 1/2	75 1/2
Ampex Corp.	84 1/2	61 1/4	67 1/4
Bausch & Lomb Optical	35 3/8	27	31 5/8
Beckman Instruments	74	36 1/4	56 1/2
Bell & Howell	73	58 1/2	64 1/2
Bendix Aviation	89	66	78
Boeing Airplane	46 1/2	34	34 5/8
Bullard	24 3/4	16	22 7/8
Bulova Watch	20 5/8	13 1/2	16 1/8
Burroughs	45 3/4	34 5/8	35 1/8
Carborundum	52	37 3/8	52
Cincinnati Milling Machine	46 1/2	38 3/4	43 3/4
Clevite	38 7/8	24 3/4	33
Columbia Broadcasting System	48	35	42 5/8
Consolidated Electrodynamics	42 5/8	33 3/4	35
Consolidated Electronics	47 3/4	33 1/2	44 1/2
Cornell Dubilier	29 1/4	20 3/4	25 1/8
Corning Glass	132	89 3/4	128
Curtiss Wright	39 1/2	27 1/8	34 3/4
Cutler-Hammer	91 3/4	59 1/2	80 3/4
Daystrom	49 3/4	34	40
Douglas Aircraft	59 3/4	49	49
Eastman Kodak	91 1/4	75	84 1/8
Eaton Mfg.	72	56 1/4	68 3/4
Electric Auto-Lite	48 1/2	36 1/4	43 1/4
Elgin Watch	14	9 3/4	10 1/2
Emerson Electric	69 7/8	48 1/8	59 1/2
Food Machinery & Chemical	49 3/4	40	48
Gamewell	39 1/4	27	27 1/2
Garrett	50 7/8	38	46 3/4
General Controls	39 1/4	24	31 3/4
General Dynamics	66 1/2	53 1/2	55 1/4
General Electric	84 3/4	74 5/8	79
General Instrument	38 3/8	16 1/2	28 3/8
General Mills	120 1/2	88 1/4	105 (1)
General Precision Equipment	45 1/2	31 1/2	36 1/8
General Railway Signal	39 1/4	33	33 7/8
General Tel. & Elec.	73 3/4	60	65 1/8
General Time	104 1/2	35	84 3/4
General Tire & Rubber	83	44 1/8	66 1/4
International Bus. Machines	488	385 1/2	431 1/2
International Tel. & Tel.	45 1/2	28	37 3/8
ITE Circuit Breaker	50 1/2	36 5/8	46 1/4
Litton Industries	123 7/8	72 5/8	107
Lockheed Aircraft	39 3/4	28 5/8	29
Magnavox	70	48 1/4	55 1/4
Mallory	48 3/4	36 3/8	43
Minneapolis-Honeywell	137 1/2	111 1/2	125
Minnesota Mining & Mfg.	151 1/2	111 1/2	139 1/4
Motorola	130	57 1/2	103 1/2
National Acme	63 1/2	52 1/4	58 1/2
National Cash Register	80	62 1/4	64 3/8
Neptune Meter	39 5/8	32 5/8	34 1/2
North American Aviation	52 5/8	39 1/4	46
Northrop Aircraft	44 3/4	31 1/4	35 1/8
Otis Elevator	75 1/4	61 1/2	72 3/4

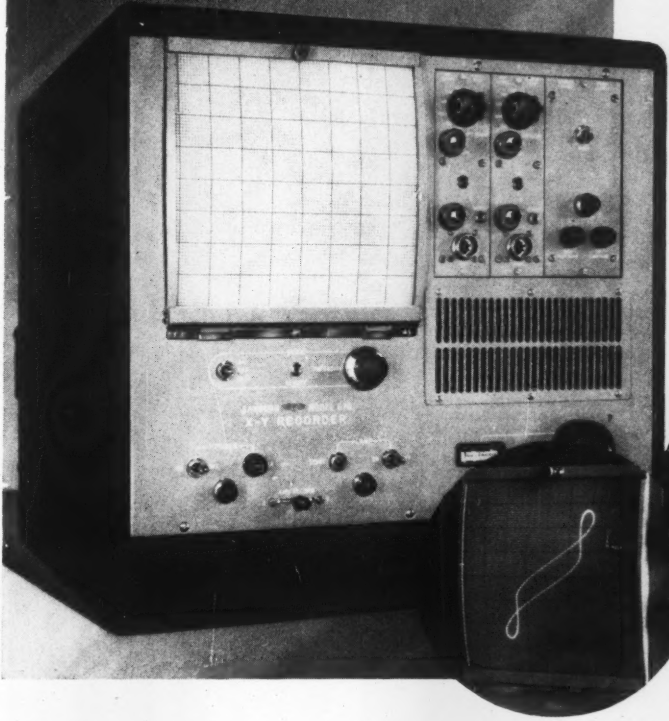
Continued on page 988

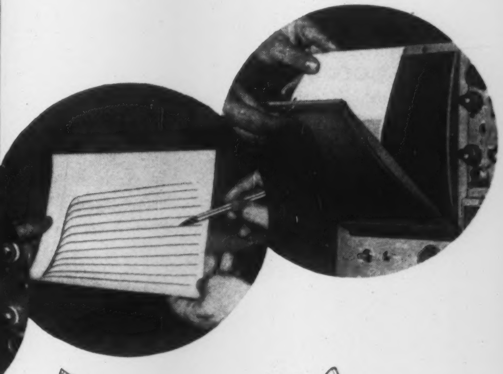
100 CPS X-Y RECORDING

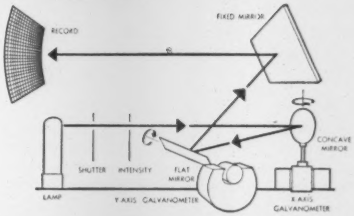
with immediate readout

THE NEW SANBORN MODEL 670 OPTICAL X-Y RECORDER HAS

- 1% linearity
- frequency response 3 db down at 130 cps independent of amplitude
- writing speeds to 2500 in/sec.
- 8" x 8" direct print paper chart
- trace monitoring on phosphorescent screen







X-Y RECORDING never before possible with electromechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of *1% of full-scale* and at trace speeds as fast as *2500 inches per second.* Square wave response exhibits no greater than ½% overshoot *at any amplitude;* sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

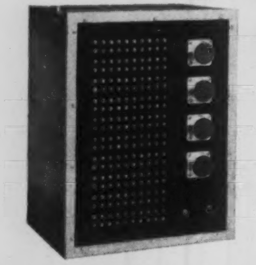
OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact, fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies—a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15¾" of panel space, or housed in its own 20" x 20" x 21¼" optional portable cabinet.

Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

CIRCLE 24 ON READER-SERVICE CARD

PACE



THERMOCOUPLE REFERENCE JUNCTION

1/5°F STABILITY

PACE BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION—

- **REFERENCE TEMPERATURES** from 25° F above ambient to 250° F — *special models for reference temperatures below ambient.*
- **CHANNEL CAPACITY** 6 to 100 channels in standard 110 volt rack or cabinet models.
- **MULTI-WIRE** junctions for thermocouple choice in each channel.
- **THERMOCOUPLE TABLES** for 150° F reference available. Write for your copy.

PACE *engineering company*

13035 Saticoy St., North Hollywood, California · Phone POplar 5-0453

CIRCLE 25 ON READER-SERVICE CARD

New York Stock Exchange: *Continued from page 986*

Philco Corp.	36 3/4	21	29 3/4
Radio Corp. of America	71	43 1/8	62 1/2
Raytheon Mfg.	73 7/8	51 1/8	52 1/8
Reliance Electric	60 3/4	42 5/8	53 1/2
Rheem Mfg.	25 5/8	18	22 3/4
Robertshaw Fulton	51 1/2	31 5/8	50
Royal McBee	24 3/8	16 1/2	16 7/8
Sangamo Electric	51 1/2	35	42 1/4
Siegler Corp.	45 1/8	26 1/2	31 1/8
Sperry Rand	28 1/4	21 1/4	25 1/8
Square D	33 1/2	26 7/8	28 3/8
Standard Coil Products	23 3/4	14 3/8	18 1/4
Starret (L.S.)	23 7/8	22	21 3/4-22(1)
Stewart-Warner	52 1/2	42 1/2	48
Telautograph	13 3/8	9	9 1/2
Texas Instruments	131	61 1/4	127 1/4
Thompson-Ramo-Wooldridge	70 1/4	56 1/4	61 1/2
Tung-Sol Electric	54 1/4	34 1/8	44 1/4
Underwood Corp.	30 7/8	20 5/8	25 5/8
Union Carbide Corp.	149 1/2	120 1/2	140 1/2
United Shoe Machinery	53 3/4	45 5/8	52 1/4
Western Union	39 3/8	29 3/4	36 5/8
Westinghouse Air Brake	38 1/2	32	34
Westinghouse Electric	97 1/2	70 1/2	90 3/8
Worthington Corp.	81	70 1/2	75 1/2

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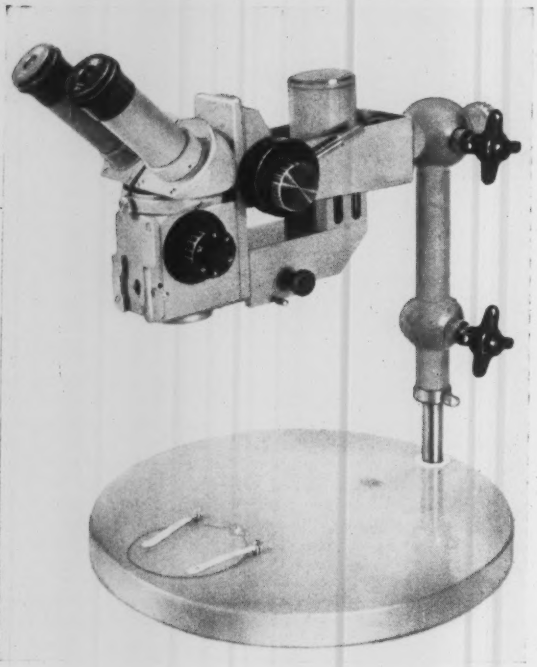
1) Not traded - Bid and Asked

OVER THE COUNTER

QUOTATION AS OF 6/16/59

	BID	ASKED
Aerovox Corp.	9 1/2	10 1/8
Aircraft Radio Corp.	46	-
Argus Corp.	38 1/4	39 1/4
Black Sivalls & Bryson Inc.	23 1/2	24 3/8
Eitel McCullough	40 1/2	41 1/2
Electro Instruments	28	29 1/2
Electronics Associates	41	43 1/2
Erie Resistor Corp.	9	9 1/2
Fisher Governor Co.	19 3/4	21 1/4
Foxboro Company	48	51
Ginnini Controls	26 1/2	28
Hagen Chemicals & Controls	26	27
Industro Transistor	5 3/4	6 5/8
Liquidometer Corp.	7 1/2	9
W. L. Maxson	12 1/4	12 3/4
Penn Controls	22	23
Speer Carbon, Inc..	44	46
Sprague Electric	46 1/2	48
Taylor Instruments	32 1/2	34 1/2
Telecomputing Corp.	11 7/8	12 1/2
Topp Industries	13 1/4	14
Varian Associates	31	32 1/2
Vitro Corp. of America	13 1/4	14



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EPI-TECHNOSCOPE

MADE IN WEST GERMANY

A new, modern stereoscopic binocular microscope eminently suited for industrial inspections and examinations.

Intense illumination parallel with line of vision. Erect, plastic image even in deep cavities.

Free working distance of 8 inches. Magnification changing device provides rapid succession of 6.3x, 10x, 16x, 25x and 40x magnifications.

Write for free detailed literature.

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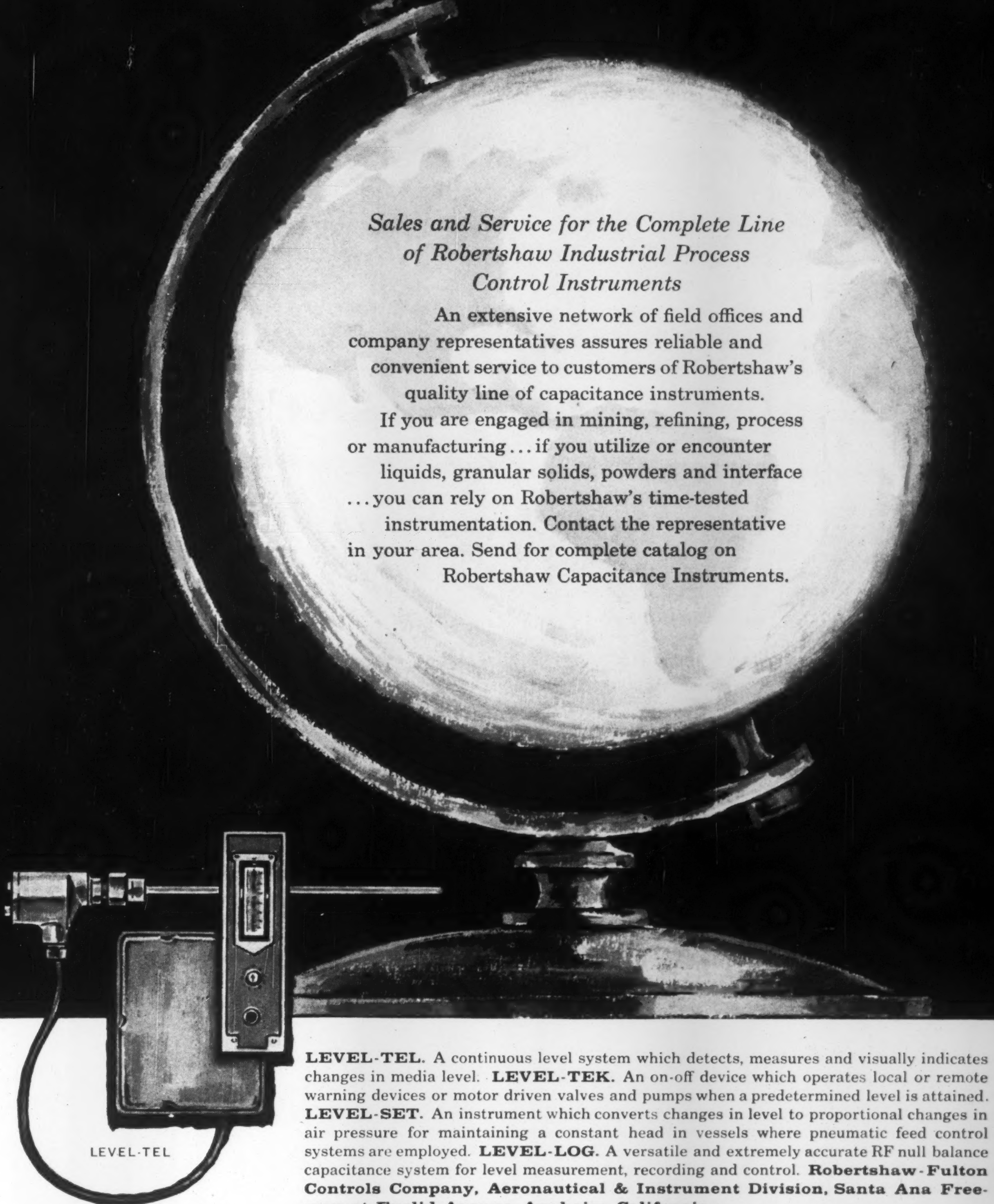
GUARANTEED UNINTERRUPTED REPAIR SERVICE

CIRCLE 26 ON READER-SERVICE CARD

There's a Robertshaw Representative Almost Everywhere



Sales and Service for the Complete Line of Robertshaw Industrial Process Control Instruments

An extensive network of field offices and company representatives assures reliable and convenient service to customers of Robertshaw's quality line of capacitance instruments.

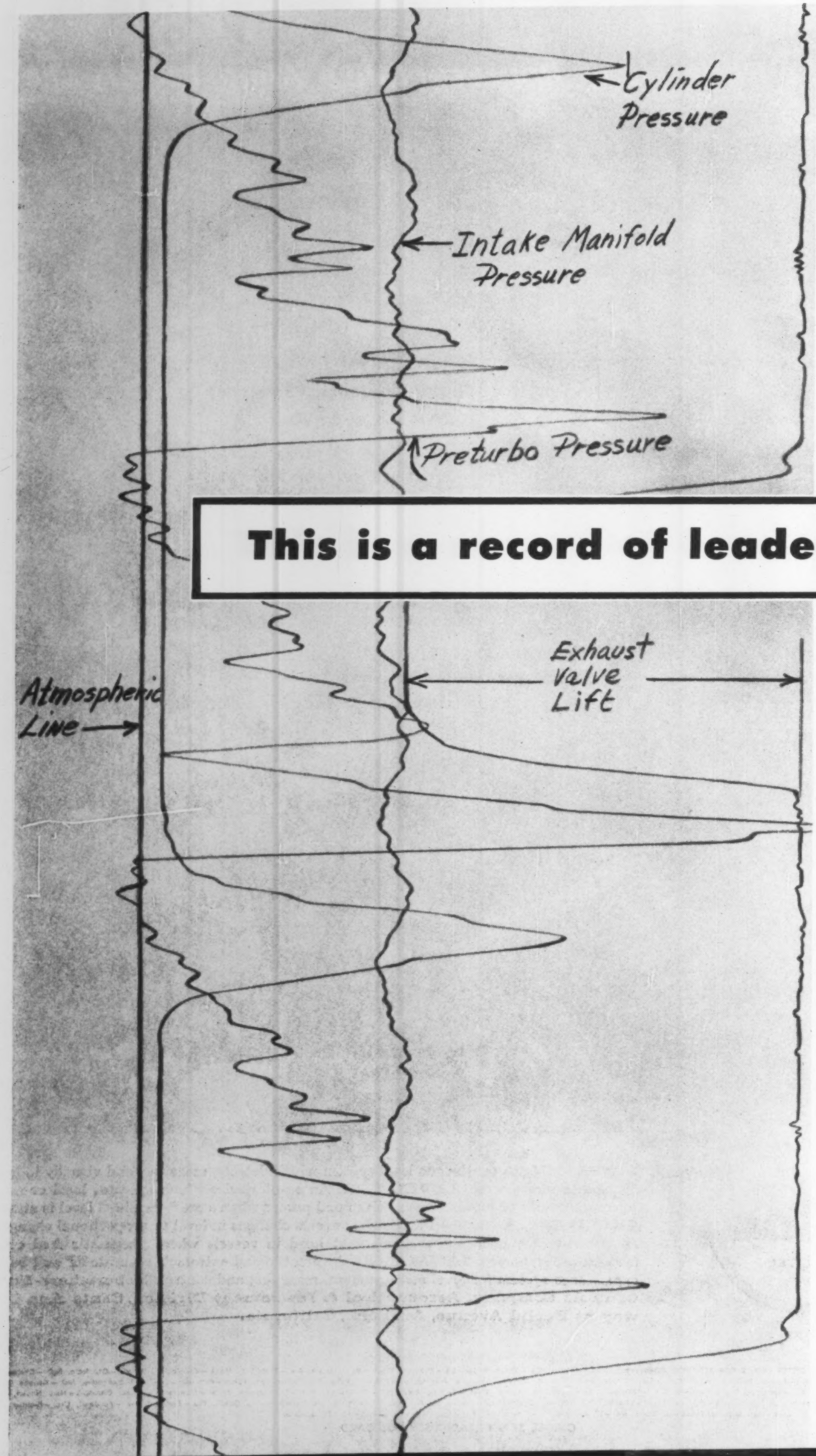
If you are engaged in mining, refining, process or manufacturing... if you utilize or encounter liquids, granular solids, powders and interface ...you can rely on Robertshaw's time-tested instrumentation. Contact the representative in your area. Send for complete catalog on Robertshaw Capacitance Instruments.

LEVEL-TEL. A continuous level system which detects, measures and visually indicates changes in media level. **LEVEL-TEK.** An on-off device which operates local or remote warning devices or motor driven valves and pumps when a predetermined level is attained. **LEVEL-SET.** An instrument which converts changes in level to proportional changes in air pressure for maintaining a constant head in vessels where pneumatic feed control systems are employed. **LEVEL-LOG.** A versatile and extremely accurate RF null balance capacitance system for level measurement, recording and control. **Robertshaw-Fulton Controls Company, Aeronautical & Instrument Division, Santa Ana Freeway at Euclid Avenue, Anaheim, California.**

OFFICES IN THESE PRINCIPAL CITIES—WRITE FOR ADDRESS: Albuquerque, N.M.—Atlanta, Ga.—Baton Rouge, La.—Billings, Mont.—Birmingham, Ala.—Brookline, Mass.—Charleston, W. Va.—Charlotte, N.C.—Chicago, Ill.—Cincinnati, Ohio—Cleveland, Ohio—Dallas, Texas—Denver, Colo.—Des Moines, Iowa—Detroit, Mich.—Edmonton, Alberta, CANADA—El Paso, Texas—Houston, Texas—Huntington, N.Y.—Indianapolis, Ind.—Kansas City, Mo.—Kingsport, Tenn.—Louisville, Ky.—Lubbock, Texas—Marion, N.C.—Memphis, Tenn.—Mercer Island, Wash.—Mexico City, D.F.—Milwaukee, Wis.—Minneapolis, Minn.—Montreal, Quebec, CANADA—New Haven, Conn.—New Orleans, La.—North Vancouver, B.C., CANADA—Odessa, Texas—Omaha, Neb.—Orinda, Calif.—Pasadena, Calif.—Phoenix, Ariz.—Pittsburgh, Pa.—Pompano Beach, Fla.—Portland, Me.—Portland, Ore.—Richland, Wash.—Rochester, N.Y.—Salt Lake City, Utah—San Antonio, Texas—St. Louis, Mo.—Shreveport, La.—Springfield, Pa.—Toronto, Ontario, CANADA—Tulsa, Okla.

CIRCLE 27 ON READER-SERVICE CARD

This is a record of leadership



CIRCLE 27 ON READER-SERVICE CARD

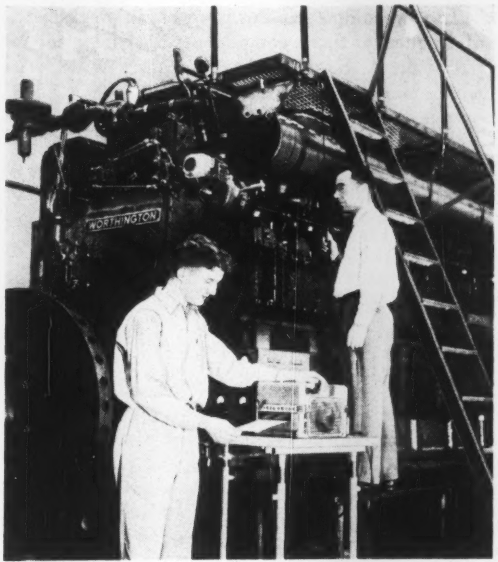
The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

The Visicorder used in these tests makes a direct, instantly-readable record of the pressure variations in the exhaust manifold, cylinder, and intake manifold to determine optimum valve timing and engine configuration. The Visicorder also produces a permanent record of strain gauge measurements taken on the frame and other critical engine parts.

For the manifold and cylinder pressures, strain gauge pressure transducers and a strain gauge amplifier were used. For the valve lift patterns, a linear potentiometer powered with a small battery was connected directly to the Visicorder.

Analysis of these data has led to changes in the Tripower engine for best performance.

in diesel engine research



Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tripower with a Honeywell 906 Visicorder.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin
Minneapolis-Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

Honeywell

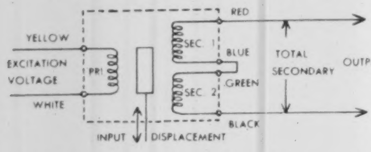
Industrial Products Group

CIRCLE 28 ON READER-SERVICE CARD

briefs

Linear Motion Measurement

The Linearsyn is a linear motion displacement pick-off of the differential transformer type . . . Consisting of a coil assembly and a movable magnetic core, it may be used to measure any physical variable capable of conversion to a relative displacement (as small as .000001 inch) between core and coil assembly. The coil assembly is three coaxial coils wound in proximity on a tubular form, hermetically sealed in either a molded laminated phenolic jacket (unshielded series) or a rugged steel magnetic and electrostatic jacket (shielded series).



Linearsyn operation is the linear change in flux linkage between the excitation winding and the secondary windings when the high permeability core is displaced. Normally the primary coil is equidistant from the two balanced secondary coils at either end of the coil assembly. When the primary is energized with alternating current, voltages are induced in the two secondary windings. The magnitude of induced voltage is accurately proportional to the displacement of the core and depends on the position of the core relative to the coil assembly.—(*From new 4-page Bulletin "Linearsyn," Sanborn Co., Waltham 54, Mass.*)

FOR THIS LITERATURE CIRCLE 140 ON READER SERVICE CARD

Valve Wall Chart

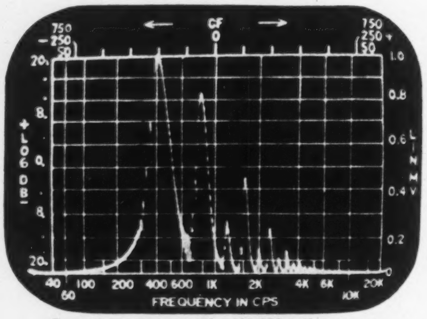
New Automatic Valve Wall Chart No. 59 . . . features ready reference data on the company's varied line of hydronic heating controls, relief valves, pressure regulators and safety devices. Four completely new valve series are illustrated for the first time. Chart is produced the same size as a standard file folder and scored for easy folding. Chart opens to full 12″ x 18″.—(*From new Valve Wall Chart, Cash-Acme, P. O. Box 191, Decatur, Ill.*)

CASH-ACME®
A. W. CASH VALVE MFG. CO.
RELIEF VALVES and SAFETY DEVICES

FOR THIS LITERATURE CIRCLE 141 ON READER SERVICE CARD

Sonic Analyzer

Panoramic Sonic Analyzers, Models AP-1 and LP-1 are scanning heterodyne type instruments which automatically separate the frequency components of a complex audio wave and simultaneously measure their frequency and magnitude. By electronic means, the Panoramic Sonic Analyzer tunes repetitively, once per second, at a logarithmic rate, through a frequency range extending from 40-20,000 c.p.s. As the wave components are progressively tuned through, they are spectrographically displayed on a cathode-ray tube screen as vertical deflections—or pips—distributed horizontally in order of frequency. The height of each deflection indicates either the relative or absolute magnitude of its corresponding component.



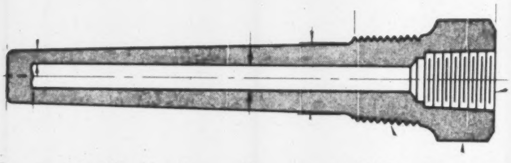
Frequency components of a 400 CPS half wave presented on log frequency scale and log amplitude.

The sweeping oscillator progressively scans, in order of frequency, those components appearing at the output of the A. F. amplifier to produce a sum frequency which is applied to a sharply tuned I. F. section. The output voltage of the component is detected, amplified and applied to the vertical deflection plates of the cathode ray tube, a linear sawtooth voltage being applied to the horizontal deflection plates.—(*From new 6-page Bulletin "AP-1, LP-1," Panoramic Radio Products, Inc., 520 South Fulton Ave., Mount Vernon, N. Y.*)

FOR THIS LITERATURE CIRCLE 142 ON READER SERVICE CARD

Thermocouple Wells

Trinity Bar Stock threaded thermocouple wells are offered in a variety of designs for a wide range of industrial applications. Standard materials are 304SS, 316SS, 347SS, 410SS, Monel, Nickel, Steel, Inconel, Carpenter 20, Hardware Bronze, and Everdur 1010. Other materials available on special order. Standard lengths are 3½″, 6″, 8″, 10″, 12″, 18″, and 24″. Other lengths are available on special order. Lagging extension can be provided as required.—(*From new 8-page Catalog "Thermowells for Thermocouples," Trinity Equipment Corp., Cortland, N. Y.*)

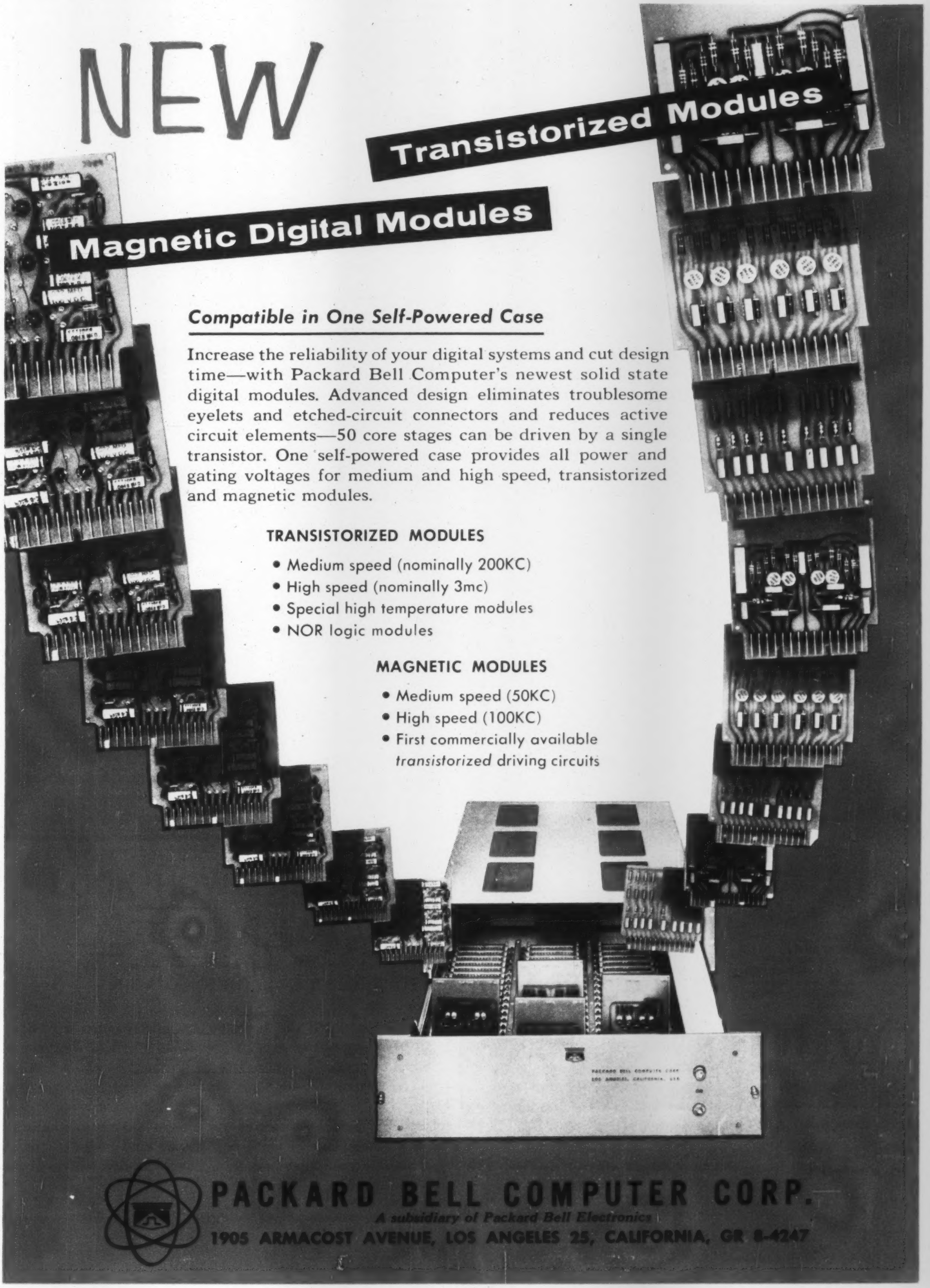


FOR THIS LITERATURE CIRCLE 143 ON READER SERVICE CARD

NEW

Transistorized Modules

Magnetic Digital Modules



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- High speed (nominally 3mc)
- Special high temperature modules
- NOR logic modules

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- First commercially available *transistorized* driving circuits

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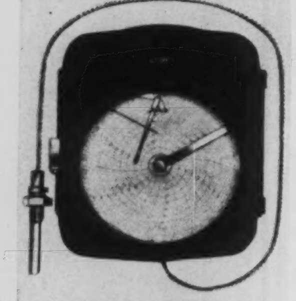
CIRCLE 29 ON READER-SERVICE CARD

FIG. D-32
MULTI-ANGLE
ADJUSTABLE
DIAL THERMOMETER



RECTANGULAR CASE
RECORDING
THERMOMETER
with Separable
Socket Connection

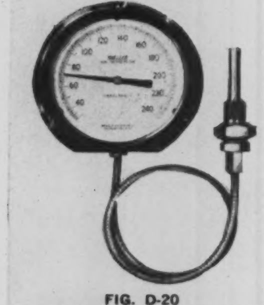


FIG. D-20
REMOTE
READING TYPE
DIAL THERMOMETER
with Separable
Socket Connection

Accuracy at every degree... that is what's built into MOELLER Dial Indicating and Recording Thermometers

Dependability has been the trademark of Moeller Instrument Co. for 91 years. Over that time it has been our pride to engineer and manufacture temperature indicating instruments of the highest quality and finest precision. Moeller Dial Indicating and Recording Thermometers have been specially designed for temperature sensitivity and for ruggedness under adverse installation conditions. Uniform scale divisions permit easy, accurate readings. Scale ranges from −40°F. to +1000° F. (or centigrade equivalent).

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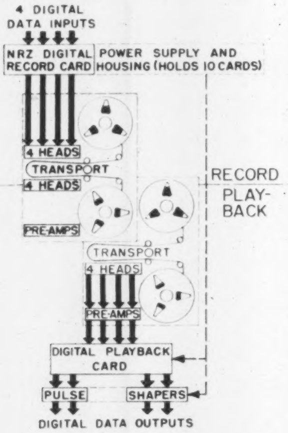
CIRCLE 30 ON READER-SERVICE CARD

Digital Recording

Equipment: For each four or less tracks, one Honeywell NRZ digital recording card. One digital electronic housing and power supply for every 10 or less recording and playback cards. For each track, one head in head stack assembly.

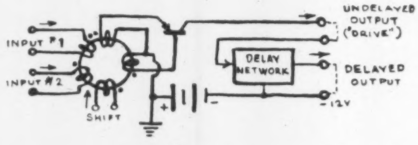

4 DIGITAL DATA INPUTS
NRZ DIGITAL RECORD CARD
POWER SUPPLY AND HOUSING (HOLDS 10 CARDS)
4 HEADS
TRANSPORT
4 HEADS
PRE-AMPS
RECORD
PLAY-BACK
TRANSPORT
4 HEADS
PRE-AMPS
DIGITAL PLAYBACK CARD
PULSE
SHAPERS
DIGITAL DATA OUTPUTS

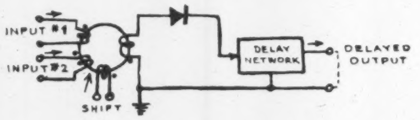
Input: Positive-going pulses, minimum 3 to maximum 20 volts peak, 5 volts per microsecond rise time. —(*From new* 28-*page Catalog* DC3171, *Minneapolis-Honeywell Regulator Co., Davies Div.,* 10721 *Hanna St., Beltsville, Md.*)

FOR THIS LITERATURE CIRCLE 144 ON READER SERVICE CARD

Magnetic Core Logic

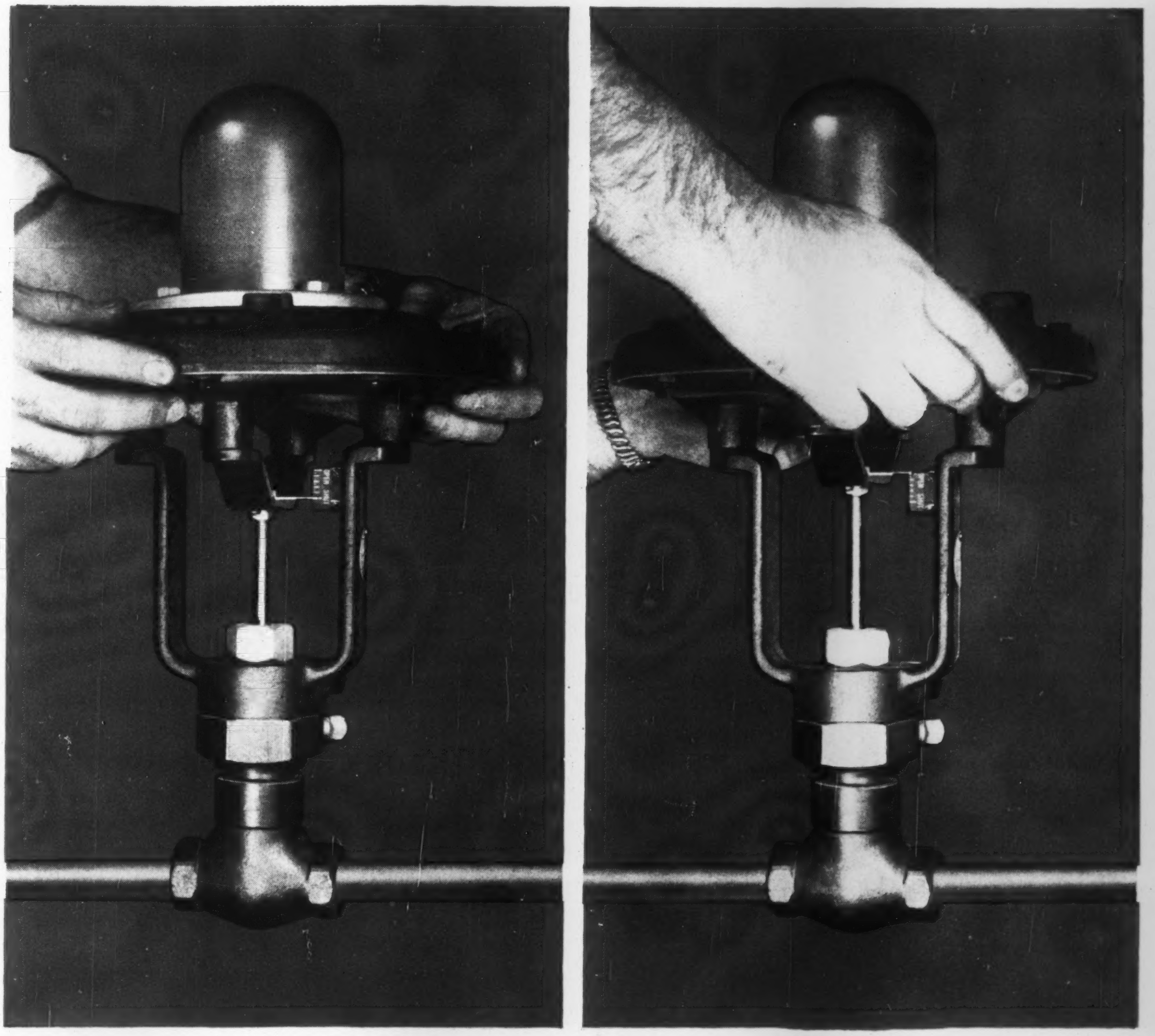
Below is a typical CTL (core-transistor-logic) circuit . . . it consists of a single magnetic core, two "input" (or "inhibit") windings, a shift winding, and an output circuit consisting to two windings, a transistor amplifier, and a delay and impedance-matching network.


INPUT #1
INPUT #2
SHIFT
DELAY NETWORK
UNDELAYED OUTPUT ("DRIVE")
DELAYED OUTPUT
+
−
−12V


INPUT #1
INPUT #2
SHIFT
DELAY NETWORK
DELAYED OUTPUT

Above is the CDL (core-diode-logic) circuit. The only *schematic* difference appears to be in the output circuit, in which a diode is used in place of the transistor, and this eliminates the need for a "base winding"; but there are actually significant performance differences between the designs.—(*From new* 16-*page Catalog* 12,851, *DI/AN Controls, Inc.,* 40 *Leon St., Boston* 15, *Mass.*)

FOR THIS LITERATURE CIRCLE 145 ON READER SERVICE CARD



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*Reg. U.S. Pat. Off.

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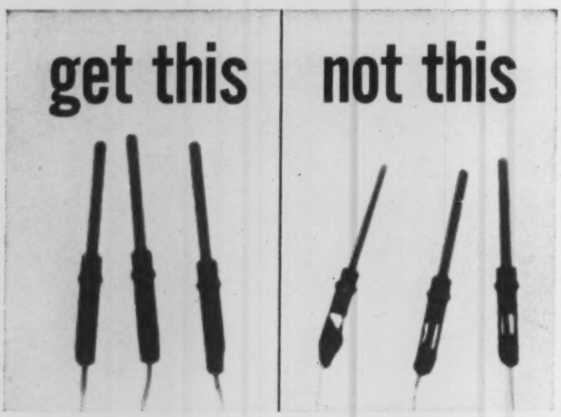
CIRCLE 31 ON READER-SERVICE CARD



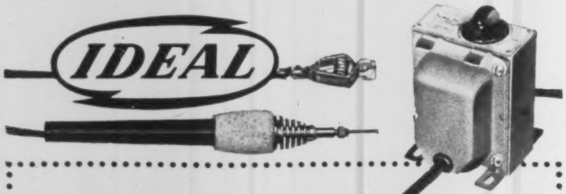
Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

	Conduction Method		Resistance Method	
Pin No.	Length of void	% of void	Length of void	% of void
1	0.12″	40	0.00″	0
2	0.12″	40	0.00″	0
3	0.07″	23	0.05″	17
4	0.18″	60	0.00″	0
5	0.06″	20	0.06″	20
6	0.05″	17	0.04″	13
7	0.02″	7	0.05″	17
8	0.08″	27	0.01″	3
9	0.09″	30	0.07″	23
10	0.12″	40	0.09″	30
11	0.15″	50	0.04″	13
12	0.12″	40	0.06″	20
13	0.09″	30	0.01″	3
14	0.12″	40	0.08″	27
15	0.11″	37	0.02″	7
16	0.10″	33	0.04″	13
17	0.07″	23	0.04″	13
18	0.09″	30	0.09″	30
19	0.11″	37	0.10″	33
20	0.11″	37	0.06″	20
21	0.05″	17	0.01″	3
22	0.15″	50	0.00″	0
23	0.11″	37	0.05″	17
24			0.07″	23



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Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

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Company____________________________

Address____________________________

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CIRCLE 32 ON READER-SERVICE CARD

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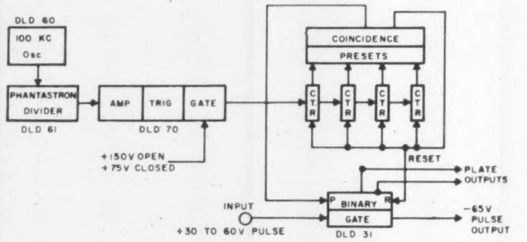


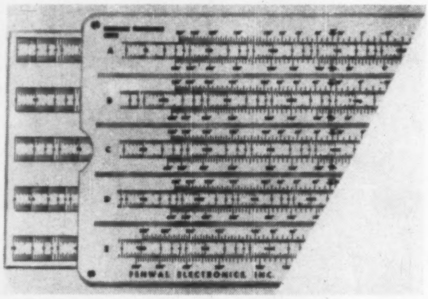
Figure shows a building-block version of the time interval circuits wherein the time between successive negative or positive pulses is measured. After the preset display time the circuit resets and is ready for the next reading. The reset pulse is available externally. Either the crystal controlled oscillator (as shown) or the 60 cycle line frequency may be used as the time base.—(*From new* 13-*page Pamphlet "Digitrol Building Blocks," Electro Precision Corp., P. O. Box* 669, *Arkadelphia, Ark.*)

FOR THIS LITERATURE CIRCLE 146 ON READER SERVICE CARD

Thermistor Computer

Dissipation constant is the amount of power in milliwatts which by self heat will raise the temperature of thermistor 1° C above its surroundings.

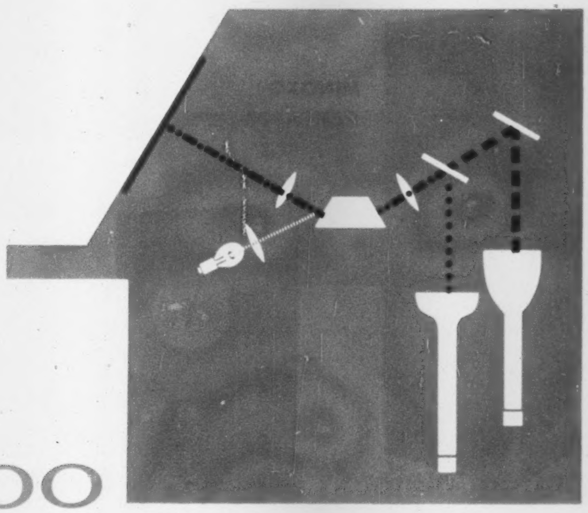
Time constant is the time required in seconds for the thermistor to change its own temperature 63% of the way from its original value to the value impressed upon it in a step change.



Dissipation constant and time constant are measured at 25° C in still air with the thermistor suspended by its leads. If it has no leads, it is mounted in contact with a large copper block . . .

1. Place arrow opposite physical shape and resistance at 25° C desired. 2. Read curve number in Resistance Temperature Curve window. 3. Set resistance desired opposite 25° C on appropriate curve on opposite side of slide rule. 4. Read resistance at all other temperature points directly.—(*From new slide rule available for* $1 *from Fenwal Electronics, Inc., Framingham, Mass.*)

FOR THIS LITERATURE CIRCLE 147 ON READER SERVICE CARD



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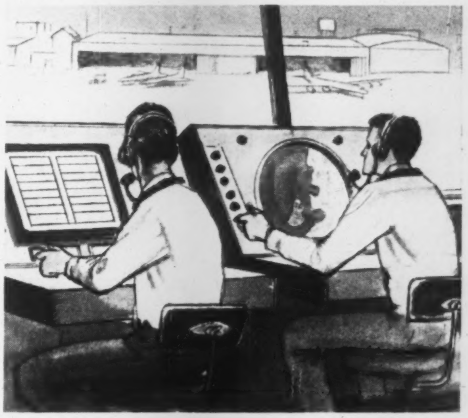

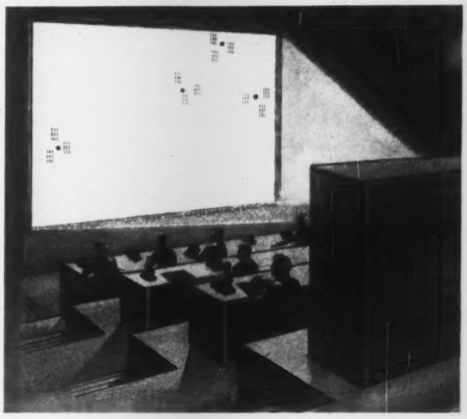

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STROMBERG-CARLSON DIVISION

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for detection and measurement of oxygen or hydrogen impurities in other gases

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SUPER-SENSITIVE DEOXO INDICATOR . . . measures oxygen or hydrogen present as impurities in other gases—from 2 to 200 parts per million oxygen and 4 to 400 parts per million hydrogen. Dual range permits measurement up to .25% oxygen or .50% hydrogen. Send for literature.

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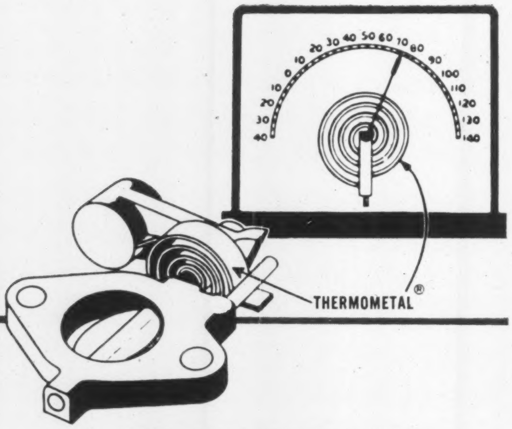

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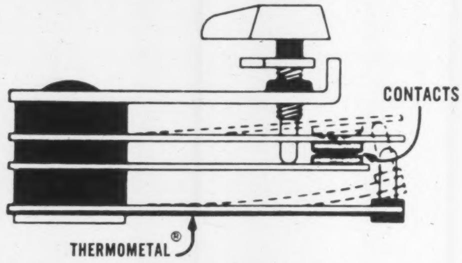

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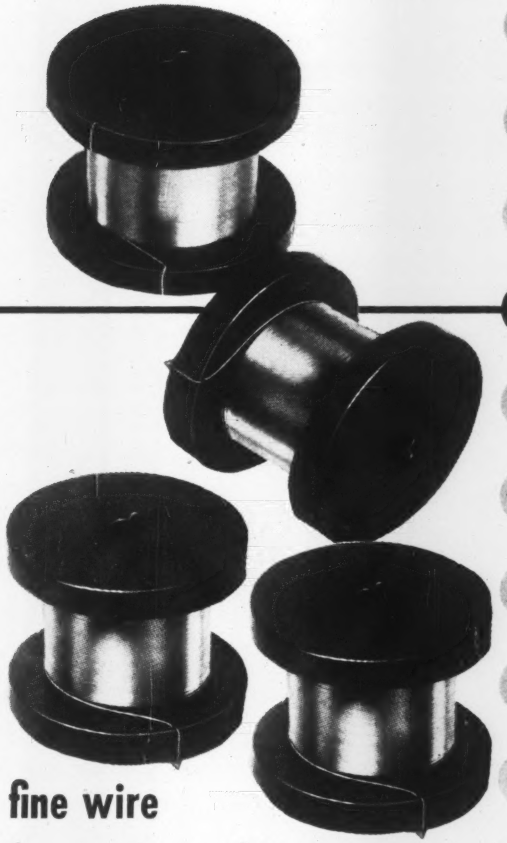
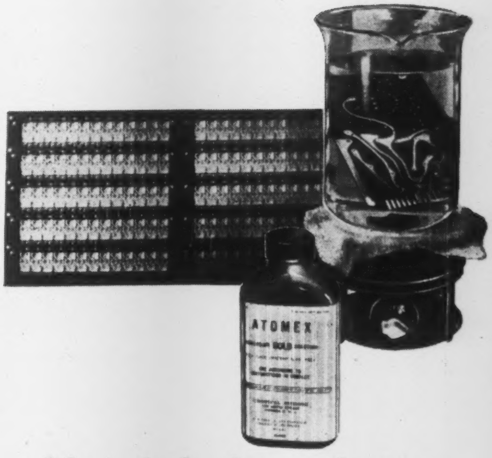
INDICATOR—CIRCLE 34 ON INQUIRY CARD

THERMOMETAL—CIRCLE 35 ON INQUIRY CARD





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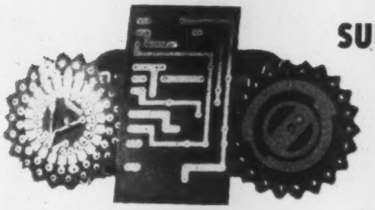

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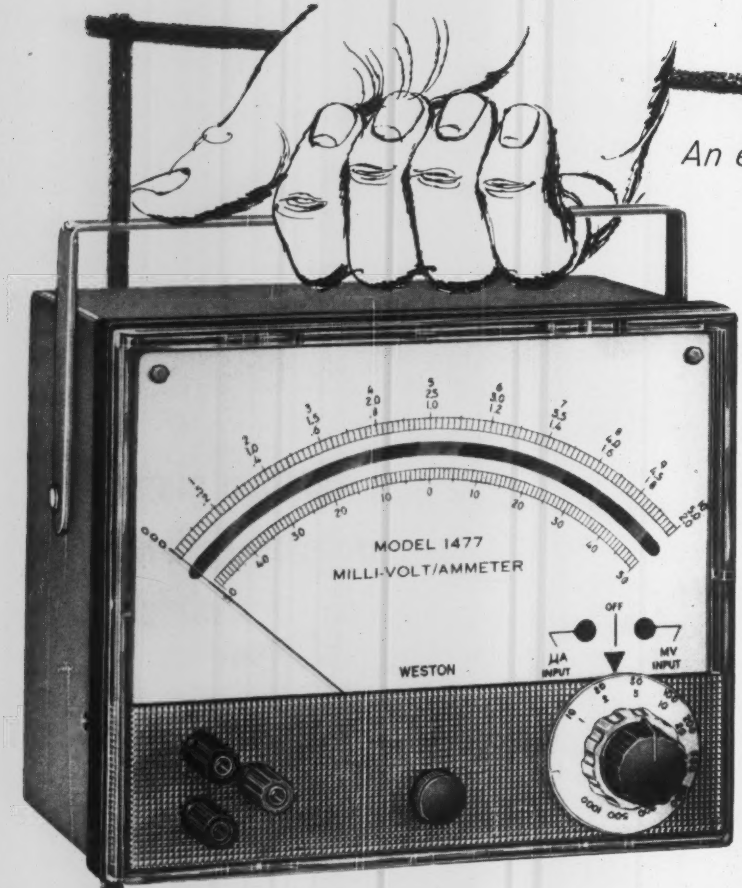
PLATING—CIRCLE 37 ON INQUIRY CARD



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CIRCLE 38 ON READER-SERVICE CARD

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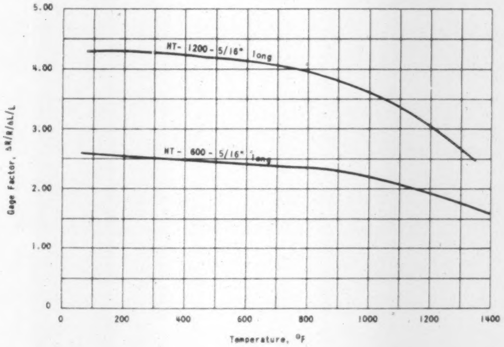
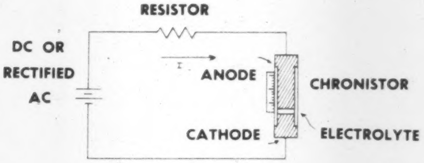


The HT type strain gage is available with either flat or round leads. The flat leads are particularly recommended for testing in high force fields, such as are encountered on compressor and turbine blades of turbojet engines. A prime consideration for vibration studies is the fact that the strain gage is completely free of spot welds.—*(From new 4-page Folder F-100, High Temperature Instruments Corp., Bala-Cynwyd, Penna.)*

FOR THIS LITERATURE CIRCLE 148 ON READER SERVICE CARD

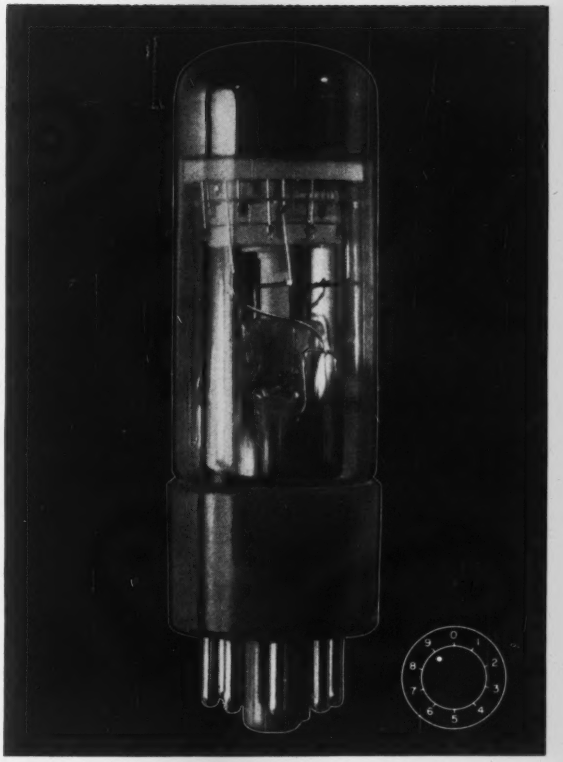
Electro-Chemical Elapsed Time Indicator

The Chronistor is in effect a miniature electro-plating bath containing an anode, cathode and electrolyte. When a DC current passes through the electrolyte, metal ions are carried from the anode to the cathode.



Since the cross-sectional area of the anode is known and the "plating efficiency" is kept near 100% while the current flow is constant . . . the length of both the cathode and anode will change with time (the anode becoming shorter and the cathode becoming longer). A time scale alongside the anode can then be calibrated directly in hours.—*(From new 2-page Form 580228, Bergen Laboratories, 247 Crooks Ave., Clifton, N. J.)*

FOR THIS LITERATURE CIRCLE 149 ON READER SERVICE CARD



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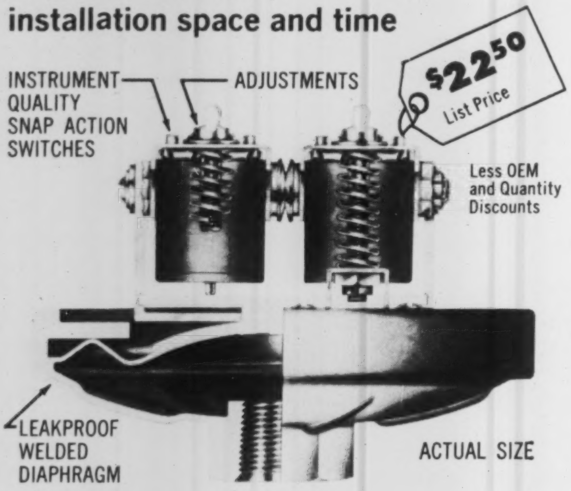

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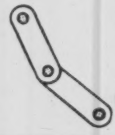
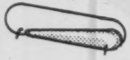
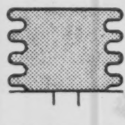
LEAKPROOF WELDED DIAPHRAGM
ACTUAL SIZE

Original Equipment Manufacturers who install all controls in a common cabinet have been quick to recognize these benefits, because the stripped Model 404 is really two pressure switches in one. At two predetermined set points in the same pressure system it actuates two independent electrical circuits (one may be A.C. and the other D.C. if necessary).

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	 LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	 LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	 ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

barksdale valves

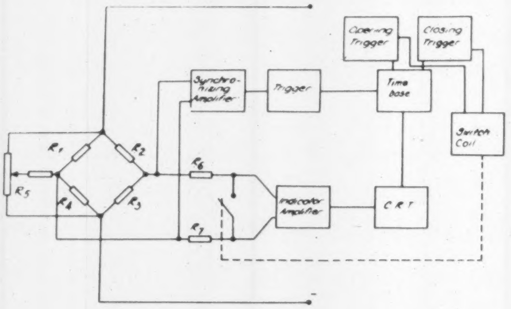
5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 40 ON READER-SERVICE CARD

Load Meter for Fatigue-Testing Machines

As a rule, measurements of dynamic phenomena cannot be carried out with the same high accuracy as those of corresponding static or semi-static phenomena . . .

A transducer, which converts the load into an electrical voltage, preferably consists of strain gauges interconnected in a Wheatstone bridge. The bridge is fed with D.C. and can be balanced by an accurate potentiometer, e.g. a 10-turn type. A static or dynamic load is converted into an equivalent output voltage from the bridge. This voltage is shorted by a switch before being applied to the amplifier and the cathode ray tube (C.R.T.). Unless the switch is open, there is no input voltage and a straight line is visible on the C.R.T. The switch can be opened and closed at any point of the curve which may be of particular interest, normally the extreme values.—(*From new 12-page Booklet, "Load Meter for Fatique-Testing Machines," Oltronix Co., 235 Underwood Dr., Atlanta 5, Ga.*)

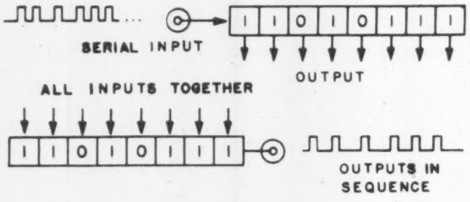


Opening Trigger
Closing Trigger
Synchronizing Amplifier
Trigger
Time base
Switch Coil
R1
R2
R5
R6
R4
R3
R7
Indicator Amplifier
C.R.T.

FOR THIS LITERATURE CIRCLE 150 ON READER SERVICE CARD

Transistor Switching Circuitry

Use the Shift Register Decode 108C for conversion of pulse train from time to space position such as serial to parallel conversion, or parallel to serial conversion.



SERIAL INPUT
1 1 0 1 0 1 1 1
OUTPUT
ALL INPUTS TOGETHER
1 1 0 1 0 1 1 1
OUTPUTS IN SEQUENCE

The 100B Pulse Generator provides accurately timed pulses for operating the 100 series logic units or for general laboratory use. The pulse interval can be selected between 10 and 100 microseconds in 1 microsecond steps, with an accuracy of ±2%.—(*From new 15-page Folder "Notes on Transistor Switching Circuits," Navigation Computer Corp., 1621 Snyder Ave., Phila. 45, Pa.*)

FOR THIS LITERATURE CIRCLE 151 ON READER SERVICE CARD

3

POWER

SPEED

COMPACTNESS

Fisher-Continental Type 480 will give you all 3 on your next

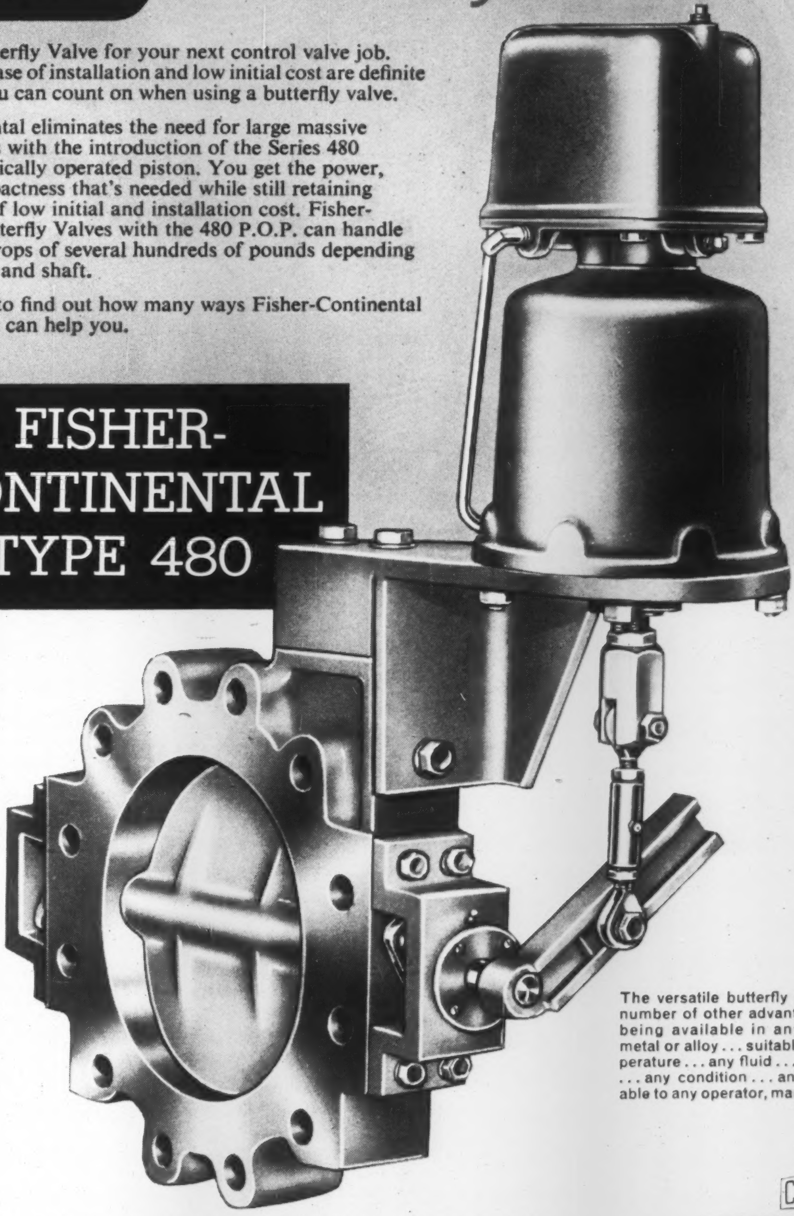
Butterfly Valve Job

Consider a Butterfly Valve for your next control valve job. Compactness, ease of installation and low initial cost are definite plus features you can count on when using a butterfly valve.

Fisher-Continental eliminates the need for large massive power actuators with the introduction of the Series 480 P.O.P. pneumatically operated piston. You get the power, speed and compactness that's needed while still retaining the advantage of low initial and installation cost. Fisher-Continental Butterfly Valves with the 480 P.O.P. can handle high pressure drops of several hundreds of pounds depending on size of body and shaft.

It will pay you to find out how many ways Fisher-Continental Butterfly Valves can help you.

FISHER-CONTINENTAL TYPE 480



The versatile butterfly valve offers a number of other advantages such as being available in any size . . . any metal or alloy . . . suitable for any temperature . . . any fluid . . . any pressure . . . any condition . . . and it is adaptable to any operator, manual or power.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PENNSYLVANIA

CONTINENTAL EQUIPMENT

FISHER® Controls

SINCE 1880

CIRCLE 41 ON READER-SERVICE CARD

Tubexperience in action

Bellows courtesy Clifford Manufacturing Company, Boston, Mass.

750,000 flexures without failure

—a common performance record for bellows formed from Superior Thin-Wall Tubing

Bellows, more sensitive than spirals and better adapted to accurate measurement of pressure and vacuum, or absolute pressure in the low and intermediate range, must withstand thousands of flexures without failure. The tubing from which they are made must be highly uniform in physical and mechanical properties and must have the invariably smooth surfaces that contribute so much to good fatigue life. It must be extremely ductile—forming pressures run as high as 5000 psi. Brazing operations used to fasten it to another assembly may subject it to temperatures up to 1800°F. It must have excellent corrosion resistant characteristics. And it must be free of carburization, dents and pickups that lead to premature fatigue failure of the bellows in service.

Thin-wall tubing of this quality—usually under .010 in. max. wall thickness and held to a tolerance spread of only one-thousandth inch—requires the skills and facilities of tubing specialists. Superior maintains production standards fully in keeping, employs special handling procedures, uses special controlled-atmosphere furnaces to provide the uniformly annealed tubing demanded. Superior tubing is produced in a wide range of analyses, in both Seamless and WELDRAWN types, and to specified IDs, ODs and wall thicknesses.

Bellows tubing is just one of many types supplied by Superior. Available are more than 120 analyses, in a wide range of sizes, and meeting almost any requirement. For a good glimpse of the field covered by Superior, send for Bulletin 41. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

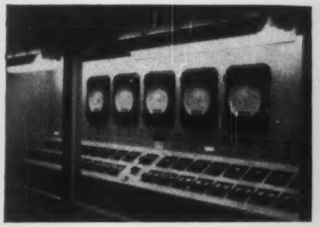
All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 42 ON READER-SERVICE CARD

HAGAN NEWSLETTER

Behind the Panel



MIDWEST UTILITY GETS POWRMAG COMBUSTION CONTROL SYSTEM

Another Hagan electronic solid state combustion control system has been contracted for by a Midwest utility for a new unit to be completed in 1961. A single furnace, single drum boiler, it will operate at 2200 psi and 1010 FTT, and have a maximum continuous capacity of 2,310,000 lb/hr steam. The Hagan systems will control combustion, fuel flow, air flow, furnace draft and pulverizer temperature and suction. Hagan's PowrMag (magnetic amplifier) components will be used for most control functions and the entire system will be solid state. Main reasons for the selection of the Hagan systems were low maintenance requirements, high accuracy and stability, and Hagan's experience. (Item H-1)

HAGAN METER AUTOMATICALLY COMPUTES "BLAST UNITS" TO BLAST FURNACES

At a leading steel company, air delivered to blast furnaces is charged to the Blast Furnace Department in terms of "blast units." A blast unit is a measure of work required to compress the air by turbo-blowers and is equivalent to 1000 kwh of electrical energy, or approximately 3,415 Btu. Blast units are calculated in terms of standard cfm air flow corrected to 15 psi gage. A common method is to integrate total air flow from air flow charts by the use of a planimeter and correlate with the pressure chart to 15 psi gage by applying certain correction factors. This method is laborious and subject to error.

However, since the installation of the Hagan Blast Unit Meter at an Eastern plant of this steel company, blast units are obtained automatically and precisely. Pneumatic signals, proportional to standard cfm and blower discharge pressure, are transmitted to the blast unit meter. The computing mechanism within the meter integrates and records blast units. Operating personnel now have an accurate and continuous record, eliminating compromise figures and manual checking. (Item H-2)

HAGAN POWRLOG TEMPERATURE CONTROLS FOR GLASS FURNACES

Fed with raw materials of special quality for the production of glass cloth, these furnaces must maintain extremely accurate temperatures in each of three sections. Initial melting is performed in the melter, maintained at 2800F. From there the glass flows to the refiner (2200F), and then to the forehearth (2200F), where the bushings through which the fiber is drawn are located. Hagan PowrLog units, with a suppressed range of 1600F to 3000F, take indications from Type R thermocouples and maintain required temperatures within 5F. Eight furnaces are under Hagan control as well as eight recuperators. Trouble-free operation, minimum maintenance and quick delivery were some of the factors which influenced the choice of Hagan as the supplier for these systems. Where even closer control is required, it is interesting to note that Hagan PowrAmp temperature controllers, sensitive to thermocouple fluctuations of one-millionth of a volt, are used to control bushing temperatures. These are held within 0.25F. (Item H-3)

GAS MIXING STATION GOES ON FULL AUTOMATIC IN HALF A DAY

This system normally utilized natural gas, but since a propane-air mixture must be used as standby, a gas mixing station was installed. Key item in the station was a standard Hagan Dual Ring Balance meter equipped with ratio control. Flow to equipment in the gas line is measured by one ring. This signal is used to control the flow of propane, which is measured by the other ring. The established ratio, resulting in a 1200 Btu propane-air mixture, is maintained throughout the range of the meter. This type of proportioning control is exact and is useful in a great many applications, including chemical feed and combustion control. The meter was installed and placed on full automatic in half a day's time. When, at a later date, demand on the station changed, the Hagan meter was changed to the new, higher range by a simple and easily made field adjustment. (Item H-4)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 707, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

If you would like more information on any of the above items, check the appropriate box below.

☐ Item H-1 ☐ Item H-2 ☐ Item H-3 ☐ Item H-4

FOR H-1 CIRCLE 43; H-2 CIRCLE 44; H-3 CIRCLE 45; H-4 CIRCLE 46; ON READER-SERVICE CARD

Tubexperience in action

Bellows courtesy Clifford
Manufacturing Company,
Boston, Mass.

750,000 flexures without failure

—a common performance record for bellows formed from Superior Thin-Wall Tubing

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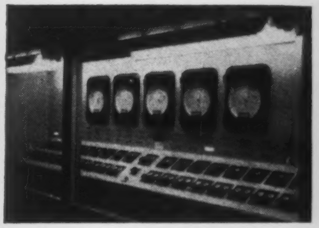
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 42 ON READER-SERVICE CARD

HAGAN NEWSLETTER
Behind the Panel



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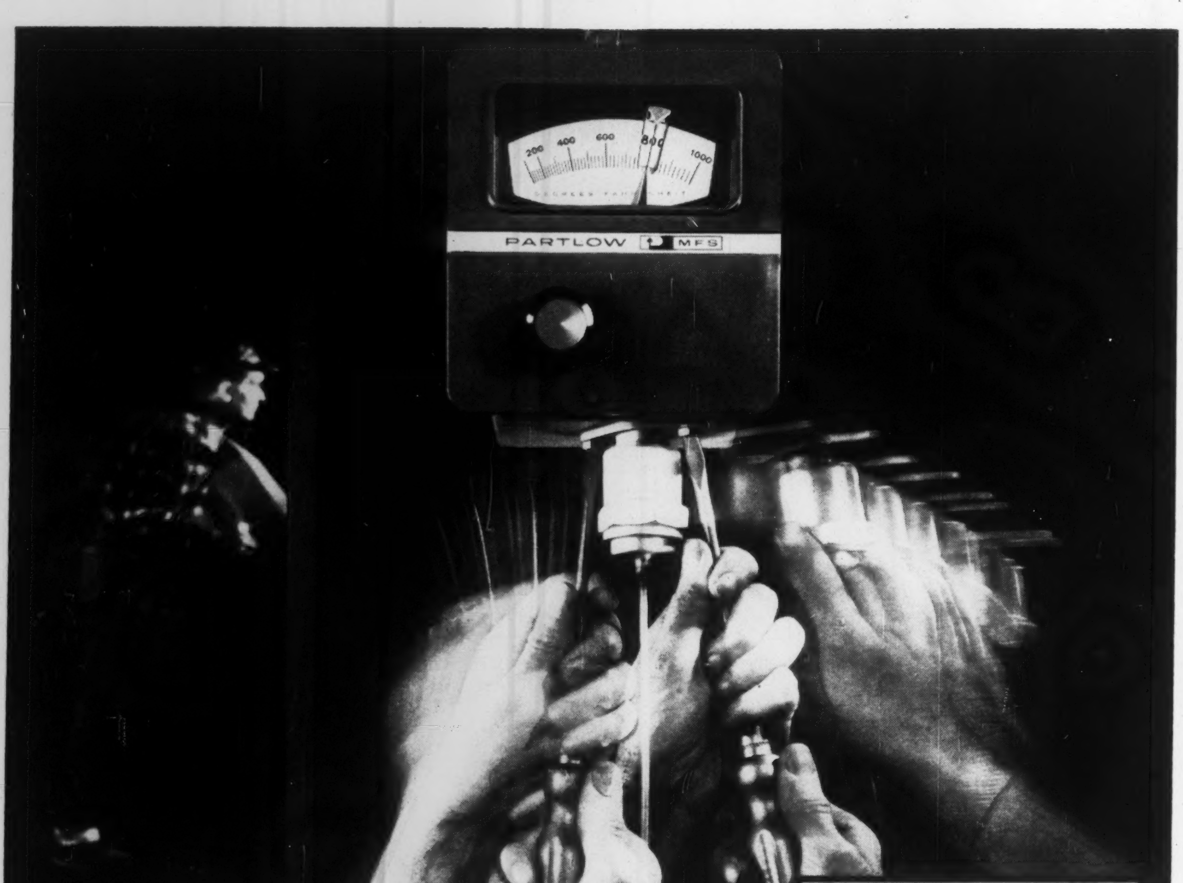
FOR H-1 CIRCLE 43; H-2 CIRCLE 44; H-3 CIRCLE 45; H-4 CIRCLE 46; ON READER-SERVICE CARD



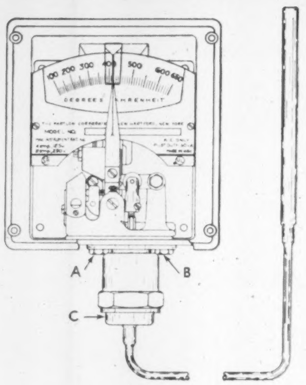
The Temperature Control Designed for Fast
"DO IT YOURSELF" MAINTENANCE
Right on the Job!

Rugged simplicity of design—along with the direct, positive power of mercury-actuation — combine to give Partlow maintenance and performance advantages no other type of temperature control can hope to equal.

Simplicity in the Partlow, for one thing, means that the control element can be changed *at the job site* in a matter of minutes with no other tool than a screwdriver . . . "Down time" is cut to an absolute minimum!

And simplicity in the Partlow also means the complete elimination of fussy electronic gadgets, delicate levers, hairsprings and other accessories that have a tendency to break down at the first trace of jar or jostle. Partlow controls are famous for their unfailingly accurate performance even under the most adverse operating conditions.

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow pneumatic, electric or self-contained gas control (recording, indicating or non-indicating), to fit your application *precisely*. For details, write The Partlow Corp., New Hartford, New York. Dept. IA-759.



Diagrammatic view of the new MFS reveals "quick-change" feature common to all Partlow controls. In case of damage, merely unscrew at points (A) and (B), and remove element (C) from case. Reverse this process, and your Partlow is ready to resume operation.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

Export Ad. Auriema, Inc.,
85 Broad St.,
New York 4, N. Y.

CIRCLE 47 ON READER-SERVICE CARD

book reviews

Regulators and Relief Valves, by Chester S. Beard and Fred D. Marton, [c 1959] Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 12, Pa., 201 p., 8¼″, paper-bound, $2.00. This second book in the Process Control Series picks up the thread of the first volume, "Control Valves" by C. S. Beard, published in 1958 with the editorial cooperation of F. D. Marton, which in a year's time nearly sold its entire first edition. The question of the need of a control valve vs the simpler regulator requiring no auxiliary power for actuation is discussed, and half of the book is devoted to the various types and applications of this simple control element. The other half of the book deals with safety and relief valves, including sizing procedure and applicable codes, and contains three chapters on emergency, shut-off, and vacuum valves.

Silicon Rectifier Handbook, Audio Devices, Inc., 620 East Dyer Rd., Santa Ana, Calif. 65 p., 8½″ x 11″, $1.00. Engineering Handbook and Catalog No. 111, January 1958.

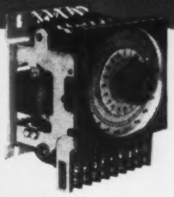
Principles and Applications of Electron Devices, by Paul D. Ankrum, International Textbook Co., Scranton 15, Pa., 667 p., 6″ x 9″, $12.00. Analysis of basic circuits using both tubes and transistors, intersperses physical background of circuit elements with specific circuit applications.

Control Engineering, by Gordon J. Murphy, [c 1959] Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J., 385 p., clothbound, $7.50, 9¼″. Covers modern automatic control theory at an intermediate level, leaning rather heavily on mathematics. Presents characteristics of a large number of control-system components. Uses frequency-response techniques. Devotes two final chapters to non-linear control theory.

Analysis of Straight-Line Data, by Forman S. Acton, [c 1959] John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 267 p., clothbound, $9.00, 9¼″. Book covers a special chapter of engineering statistics—the analysis of experimental data that can be described in terms of linear relationship.

Count Control
COMPONENTS
FOR AUTOMATING INDUSTRIAL PROCESSES

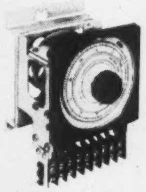
featuring adjustable count
automatic reset
10 ampere switches



model HZ4
MICROFLEX RESET COUNTER

Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.

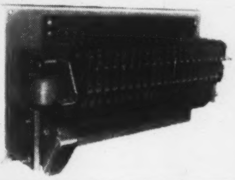
Ask for bulletin 720.



model HZ200
ADD-SUBTRACT COUNTER

Add-Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.

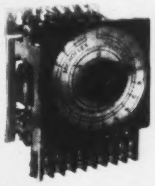
Ask for bulletin 740.



model MT
STEP SWITCH

Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.

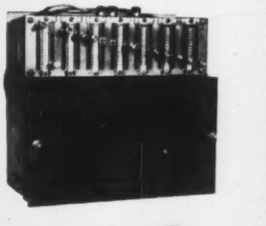
Ask for bulletin 780.



model HZ6
MICROFLEX REVOLUTION COUNTER

Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.

Ask for bulletin 730.



model HM
MULTIFLEX (*Multiple Circuit*) TIMER

Use for sequence control of 1 to 7 circuits. With shaft drive for mechanical connection to an external drive mechanism.

Ask for bulletin 130.

Write us regarding your count problem. Services of Sales Engineers in 25 district offices are available without obligation. Address Dept. IC-759.

EAGLE SIGNAL COMPANY
A DIVISION OF THE GAMEWELL COMPANY • MOLINE, ILLINOIS
Eagle Timers Save Time — Save Money

CIRCLE 48 ON READER-SERVICE CARD

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FROM Instruments Publishing Co.
SUBJECT Special Issue

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INSTRUMENTS & CONTROL SYSTEMS, 845 Ridge Ave., Pittsburgh 12, Penna.

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(I prefer one year ☐ $4; five years ☐ $10.)

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ALREADY A SUBSCRIBER? AN ASSOCIATE WOULD APPRECIATE THE OPPORTUNITY TO USE THIS COUPON.

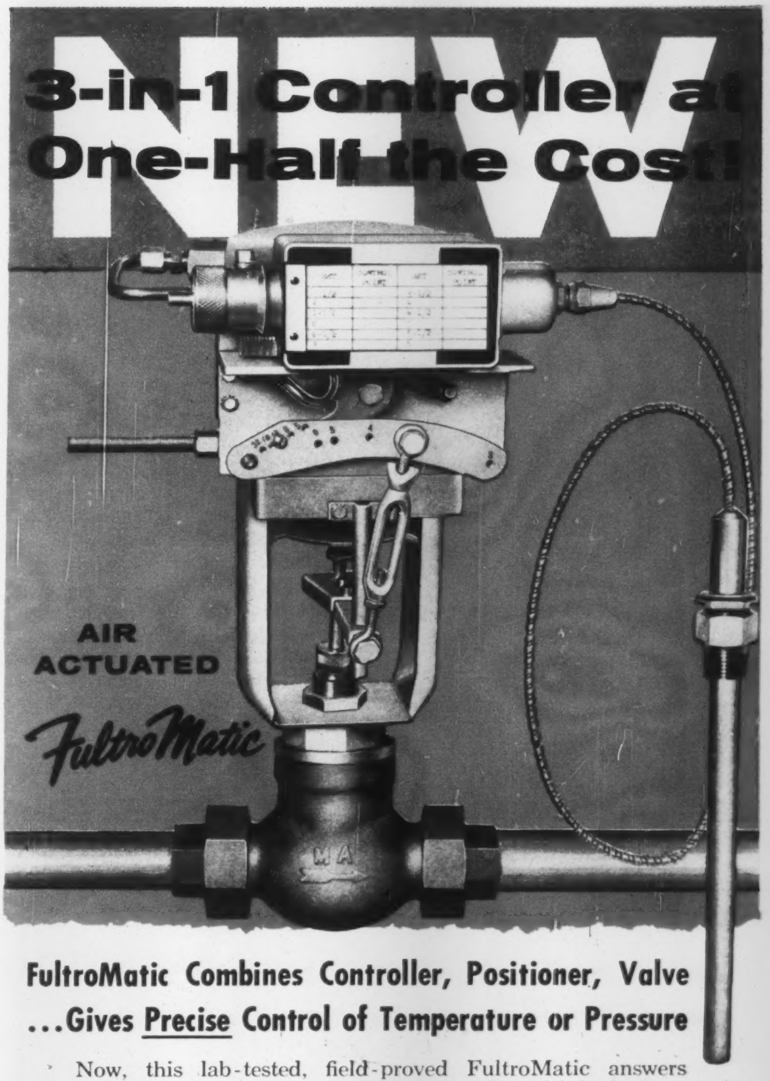
Introduction to Electronic Analog Computers, by John N. Warfield, [c 1959] Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y., 175 p., clothbound, \$6.00, $9\frac{1}{4}$″. This book discusses characteristics of computers, goes deeply into differential equations, simulation, difference equations, and systems engineering, avoiding details of the electronic and mechanical design.

Grundlagen der selbsttaetigen Regelung (Fundamentals of Automatic Control), edited by W. W. Solodownikow, German edition under the supervision of Heinrich Kindler, [c 1959] R. Oldenbourg Verlag, Munich, West Germany, 727 p., clothbound DM65.00, $9\frac{1}{2}$″. Vol. 1, titled "General Fundamentals of the Theory of Linear Automatic Control Systems," is a comprehensive work, devoting $\frac{1}{3}$ of its content to mathematical introduction, 1/5 to analysis of stability, $\frac{1}{4}$ to frequency response, and the balance to disturbance and noise.

Feedback Control Systems, by J-C Gille, M. J. Pélegrin & P. Decaulne, [c 1959] McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y., 793 p., clothbound, \$16.50, $9\frac{1}{4}$″. This translation of a book written by French engineer-scientists echoes the European and Russian state of the art up to about 1957. Philosophy and technique of presentation are European, and the mathematical level, in the French tradition, notably high. Combines linear and nonlinear theory with components of servo systems. A five-language glossary of automatic-control terms will prove valuable.

International Radio Tube Encyclopaedia (Third Edition 1958/59), by Bernard B. Babani, [c 1958] Bernards (Publishers) Ltd., The Grampians, Western Gate, London, W.6, England, 768 p., LXXXIV, clothbound, 10″. Contains listings and specs of more than 27,500 tube types from all over the world, and a preface and directions for the use of the book written in 15 languages.

The Theory and Design of Magnetic Amplifiers, by E. H. Frost-Smith, [1958], John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 480 p., clothbound, \$12.50, $8\frac{5}{8}$″. Printed in Great Britain. First in a series of Automation and Control Engineering dealing with special areas of application and/or special components primarily for the electrical engineer.



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Now, this lab-tested, field-proved FultroMatic answers today's precise control requirements with multiple features never before available in one unit . . . *at about half the cost of two- and three-unit systems!*

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- **Simplified settings** with knob, indicator, arbitrary scale.
- **Field reversibility:** control action quickly changeable.
- **Easy to install:** place valve in position, mount bulb, connect air.
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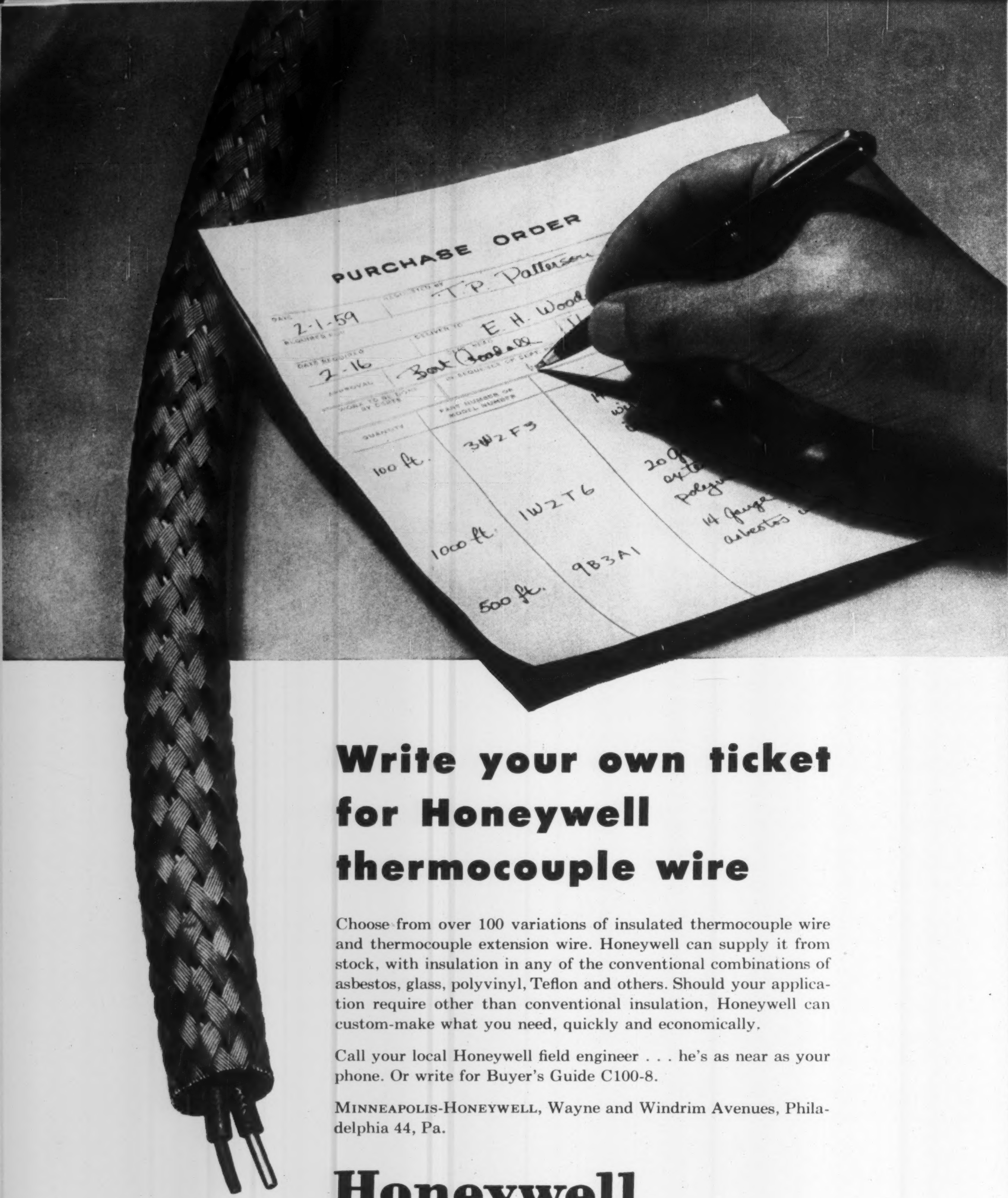
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Choose from over 100 variations of insulated thermocouple wire and thermocouple extension wire. Honeywell can supply it from stock, with insulation in any of the conventional combinations of asbestos, glass, polyvinyl, Teflon and others. Should your application require other than conventional insulation, Honeywell can custom-make what you need, quickly and economically.

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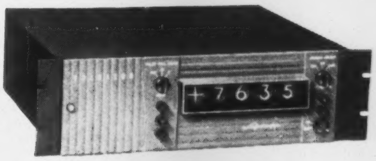
10,000 megohms? 200 volt swings? with transistors?



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Yes, it can be done! Adage Engineers have laid two widespread myths to rest! Transistors can provide high output voltage swings. Transistors can provide very high input impedances.

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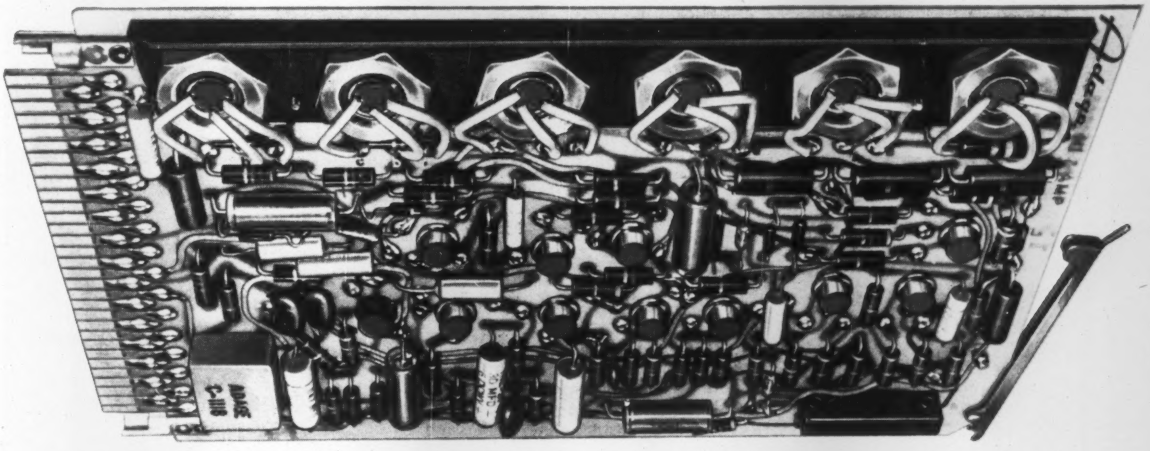
The CV-HZA functions as a direct-coupled voltage follower. Voltage gain is precisely unity. A unique semi-conductor chopper stabilizing technique results in excellent long term d.c. voltage stability. Long term reliability has been proven by extensive field testing.

This revolutionary device can be ordered as an integral pre-amplifier in Adage Voldicon voltage-to-digital conversion equipment, or it may be ordered separately. It will solve many circuit loading problems for users of Analog Computers, Automatic Test Systems, Potentiometer Measurement Equipment, etc.

Two models are presently available: ±100 volts (model CV-HZA); ±10 volts (CV-HZA10)



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PERFORMANCE SPECIFICATIONS

Recordings—Uniform, crisp, easily reproduced. Trouble-free ink writing on precision chart paper.

Channels—Two analog, plus two event markers.

Sensitivity—Maximum of 10 mv/chart line (mm); range, 10 mv to 400 v.

Input—Differential; impedance 5 megs each side to ground.

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37TH AND PERKINS **CLEVITE** CORPORATION CLEVELAND 14, OHIO

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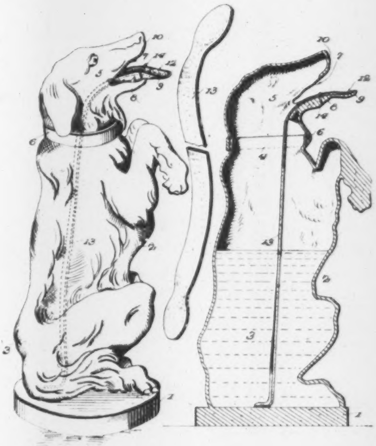
panhandle pete

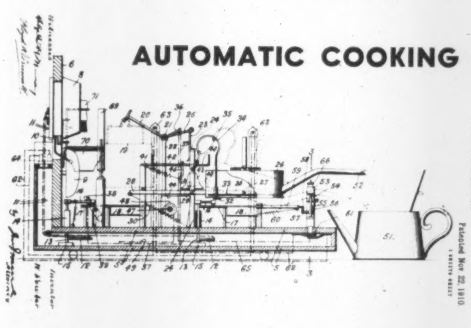
AUTOMATIC MOISTENER

This invention relates to certain improvements in moisteners for stamps, envelopes, binding tape and the like; and the objects and nature of the invention will be readily understood by those skilled in the art in the light of the following explanation of the accompanying drawings illustrating what I now believe to be the preferred mechanical expression or embodiment of my invention from among other forms, constructions and arrangements within the spirit and scope of the inventions.

Charles William Beiser
Patent 1,429,058
Patented Sept. 12, 1922



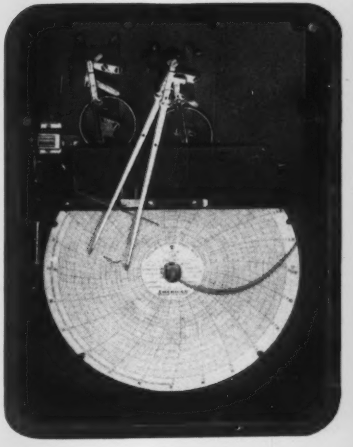
AUTOMATIC COOKING APPARATUS



This invention has reference to heating and cooking by oil and spirit stoves, and has reference more particularly to apparatus wherein the stoves are lighted automatically at a predetermined time through the medium of an alarm clock, and the kettle is adapted to automatically empty its contents into a receptacle, such as a teapot, upon such contents boiling.

Automatic apparatus for heating and cooking purposes comprising a clockwork mechanism, spring controlled match carrying devices, means connecting the match devices with the clockwork mechanism, oil spirit stoves provided with abrading surfaces for igniting the matches for the purpose of lighting the stoves, a kettle containing a bellows device and disposed above one of the stoves, heating vessels disposed above the remaining stoves, a pivotally mounted tiltable support for the kettle, a trigger device connecting the bellows device with the tiltable support and which is released from the tiltable support when the water boils and causes the kettle to tilt forwardly for emptying its contents, an extinguishing plate for the kettle stove, a spring controlled catch for holding the plate in the open position and provided with a member arranged in line with a part of the kettle which bears against it when the kettle tilts forwardly and releases the plate and extinguishes the kettle stove, a source of electricity, electric lamps, a switch and circuits connecting the lamps and said source of electricity, means connected with the spring catch for actuating the switch when the kettle tilts forwardly, and supports for the remaining heating vessels provided with means of connection with the trigger device whereby the vessels are carried above the remaining stoves and when released descend onto the stoves and extinguish the same.

Wilbur Fowler
Patent 976,646
Nov. 22, 1910



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Sales Offices in Principal Cities

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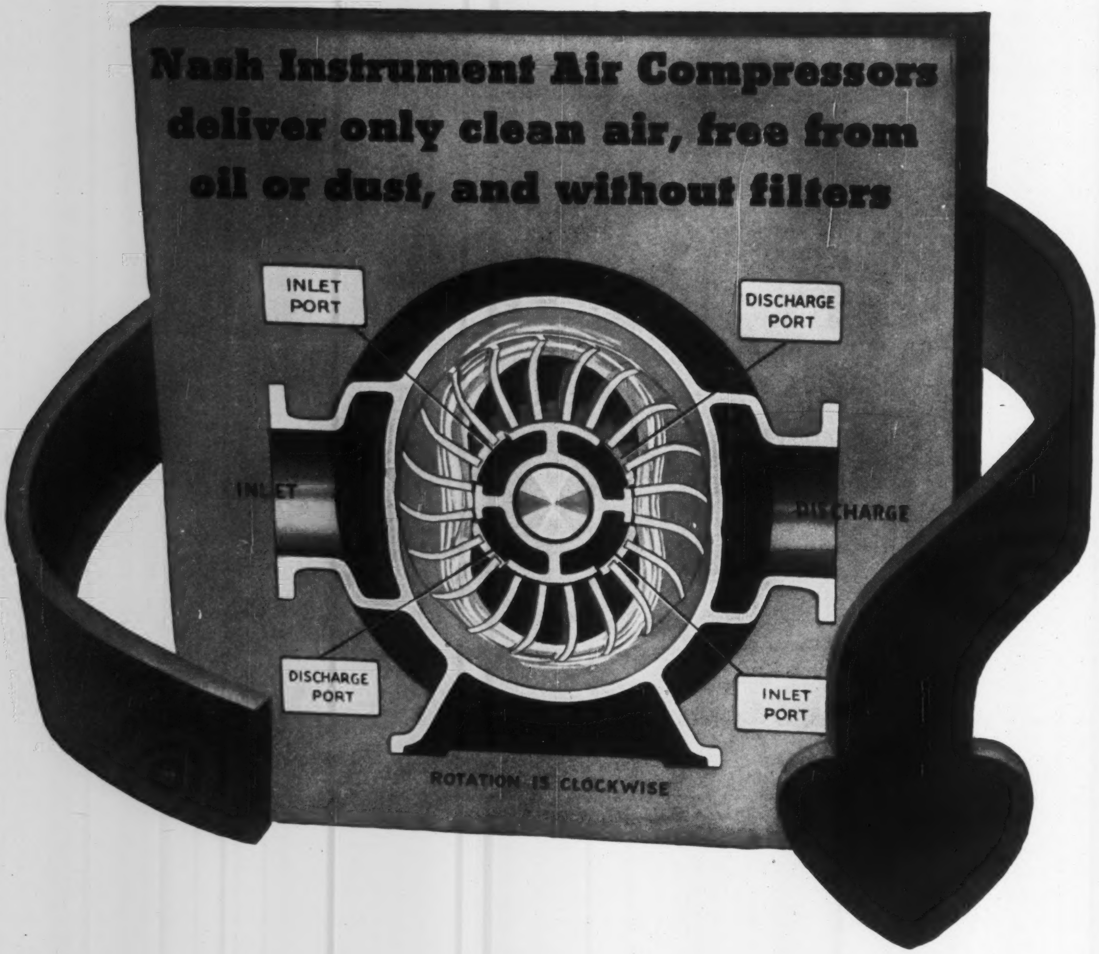
Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
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You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

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Non-pulsating pressure.
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events

August 17-28

Courses In Frontier Research On Digital Computers, sponsored by University of North Carolina, will be held on campus. For information write James G. Steagall, University Extension Div., Box 1050, Chapel Hill, N. C.

August 18-21

Western Electronic Show and Convention. San Francisco, Calif. For information write WESCON, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

August 24-26

Appalachian Gas Measurement Short Course, sponsored by University of West Virginia, will be held on campus. For information write School of Mines, Morgantown, West Virginia.

August 24-28

Gordon Research Conferences on Instrumentation, Colby Junior College, New London, New Hampshire. For information write W. George Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, Rhode Island. After June 15, write c/o Colby Junior College.

August 24-29

Infrared Spectroscopy Institute, sponsored by Fisk University, will be held on campus. For information write James R. Lawson, Fisk University, Infrared Spectroscopy Institute, Nashville 8, Tenn.

September 21-22

8th Annual Meeting, Standards Engineering Society, Somerset Hotel, Boston, Mass. For more information write Charles Ajamian, P.O. Box 538, Wayland, Mass.

September 1-3

14th National ACM Conference, Massachusetts Institute of Technology, Cambridge, Mass. For information write Frank Verzuh, MIT, Cambridge, Mass.

September 21-25

Fourteenth Annual Instrument Society of America Conference and Exhibit, International Amphitheater, Chicago, Ill. For information write F. Tabery, 3443 South Hill St., Los Angeles 7, Calif.

September 22-24

Third Industrial Nuclear Technology Conference, Morrison Hotel, Chicago, Ill. For information write L. Reiffel, Armour Research Foundation, Technology Center, Chicago 16, Ill.

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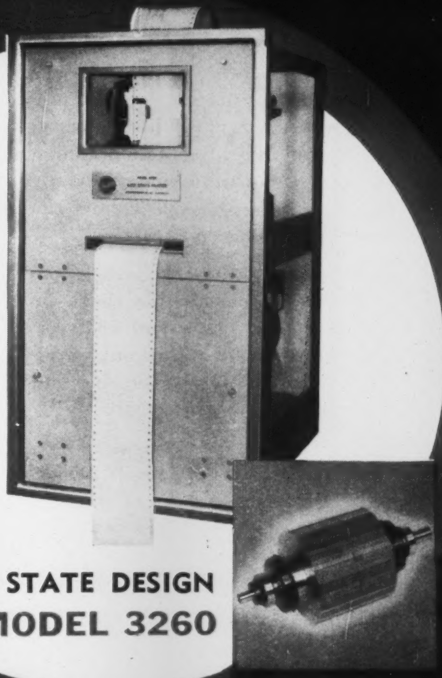

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adaptable to all digital data sources

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CIRCLE 55 ON READER-SERVICE CARD

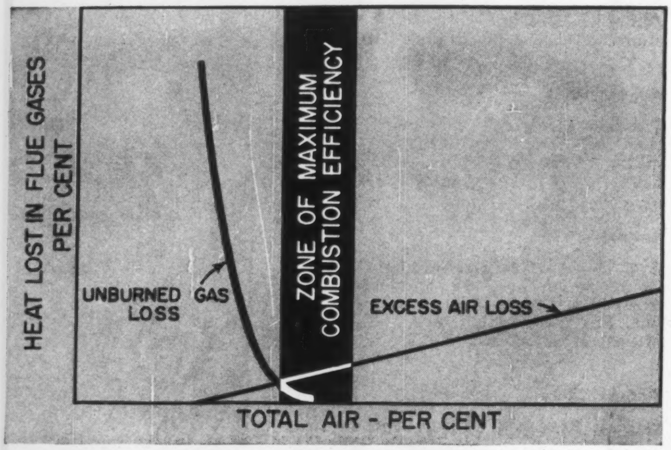
How to get maximum combustion efficiency . . . measure both combustibles and oxygen

Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

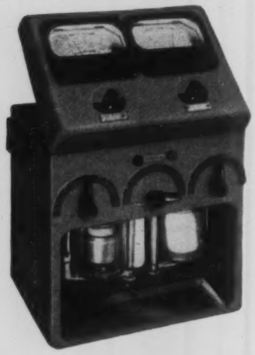
Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned, (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.

Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries. To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.



Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

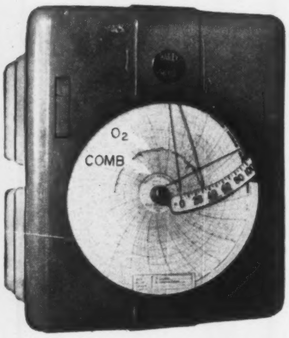
For portable use— HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

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A VITAL 100 MINUTES!

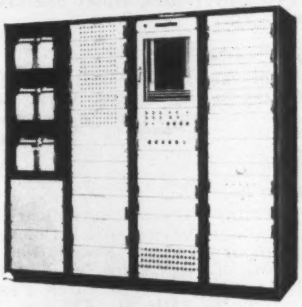
Firing Sequencer with 762 CLARE RELAYS gives automatic control

Automatic control of the countdown at the Air Force's Cape Canaveral Missile Test Center—from X minus 90 minutes to 10 minutes after a missile is fired—is in the hands of a Milgo Model III Sequencer.

The Sequencer, built by Milgo Electronic Corporation, Miami, Fla., automatically controls the myriad operations which must be performed before any missile can be launched. It is preprogrammed to recognize the precise condition that must exist during each of the operations it controls. When any other condition is detected, it will automatically hold fire until the condition is corrected. In a recent instance, it saved a Titan prototype which developed a malfunction after firing but before actual takeoff.

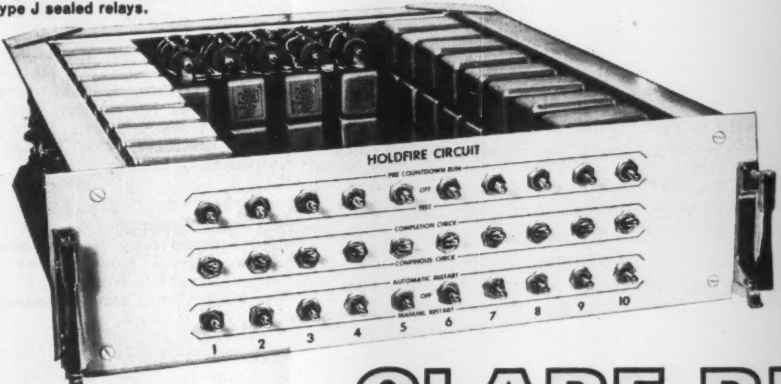
Another of these sequencers is being built by Milgo for installation at the Pacific Missile Range, Vandenberg Air Force Base, Calif.

Milgo engineers selected 762 Clare Type J and Type HG Relays for this supremely important device, and not one has ever malfunctioned. Here is convincing proof that, where the safety of personnel and of valuable equipment is at stake and the utmost accuracy is demanded, a designer who rides with Clare relays can rest assured that he has chosen wisely and well,—not necessarily the cheapest relays but certainly the very best.



Front view of Model III Sequencer which uses 762 CLARE Type J Relays and 14 CLARE Type HG Relays. Made by Milgo Electronics Co., Miami, Fla.

View of control rack of Model III Sequencer showing 56 CLARE Type J sealed relays.



CLARE RELAYS

C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois.
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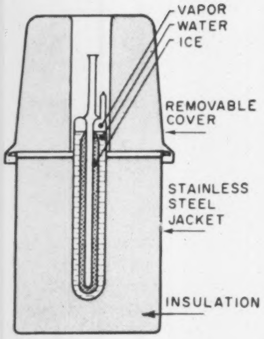
New Temperature Standard

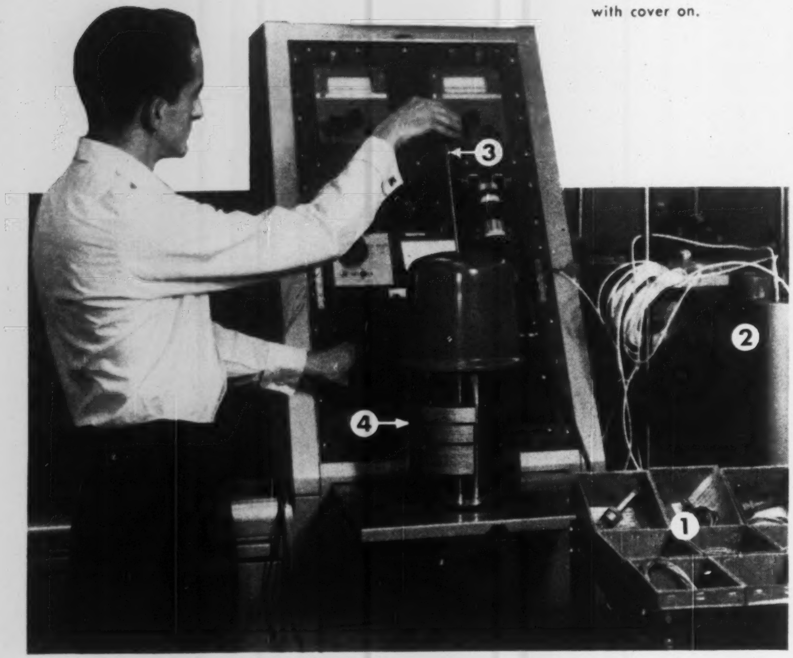
TRANS-SONICS T.M.

EQUIPHASE* CELL

assures accuracy of thermometer calibrations



Equiphase Cell shown with cover on.



The above photograph shows how an Equiphase Cell is used to assure accuracy in calibrating platinum resistance thermometers. Various types of platinum thermometers (1) to be calibrated are immersed in an ice bath (2). The temperature of the ice bath is continuously monitored by a special platinum thermometer (3) used as the working standard. Accuracy of the working standard is assured by periodic checking against the reference temperature established by the Equiphase Cell (4).

In the Equiphase Cell, pure water is partially frozen in an evacuated and non-contaminable sealed glass system to establish the triple-point-of-water (ice, water, and water-vapor at 4.58 mm Hg). By definition the triple-point-of-water is a fundamental fixed point at exactly 0.0100C on the International Temperature Scale. Equiphase Cells, meeting these exacting requirements, are now available in a convenient easy-to-use package complete with instruction booklet. Write for Equiphase Cell Technical Bulletin to Trans-Sonics, Inc., Dept. 19, Burlington, Massachusetts.

TRANS-SONICS

Precision Transducers

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EVENTS—CONTINUED

September 23-25
Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers, Shoreham Hotel, Washington, D.C. For information write John Leslie Whitlock Associates, 6044 Ninth St., North, Arlington, Virginia.

September 28-October 1
Ninth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Md. For information write James B. Davis, National Institutes of Health, Public Health Service, Bethesda 14, Md.

October 5-7
Fifth National Communications Symposium, sponsored by IRE Professional Group on Communications Systems, Hotel Utica, Utica, N. Y. For information write C. W. Gordon, 1403 Bedford St., Rome, N. Y.

October 12-14
National Electronics Conference, co-sponsored by Illinois Institute of Technology and two technical societies and two universities, Hotel Sherman, Chicago, Ill.

October 19-21
Joint Fall Meeting of URSI and IRE, El Cortez Hotel, Balboa Park, San Diego, California. For information write IRE, 1 E. 79th St., New York 21, N. Y.

October 28-29
6th Annual Computer Applications Symposium, Morrison Hotel, Chicago, Ill., Armour Research Foundation of the Univ. of Ill., Write M. J. Jans, Conf. Secy., Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

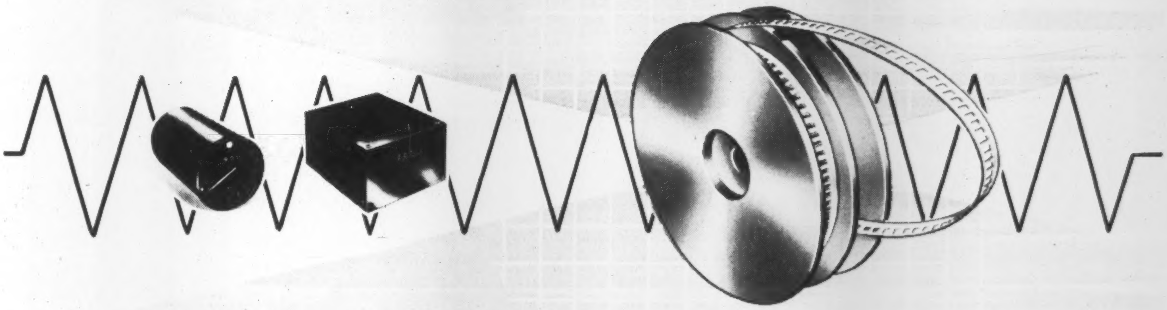
October 29-30
5th Annual Electron Devices Meeting, Shoreham Hotel, Washington, D. C., PGED-IRE, Write J. J. Lanigan, Pub. Chrman, Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

November 3-5
1959 Mid American Electronics Conference (MAECON) Midwest Research Institute, Kansas City, Mo., Sponsored by KC Section, IRE. Write Paul C. Constant, Jr., Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

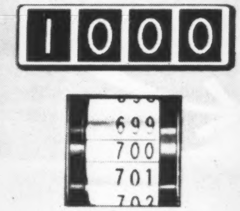
November 4-6
Sectional Meeting of Society for Applied Spectroscopy & Instrument Exhibition. Hotel New Yorker, N.Y.C. For information write M. F. Wilson, Air Reduction Corp. Research Lab., Murray Hill, N. J.

November 16-19
5th Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Mich., Sponsored by Univ. of Mich., IRE, Am. Phys. Soc., ONR, AIEE and Met. Soc of AIME. Write D. M. Grimes, Dept. of E. E., Univ. of Mich., Ann Arbor, Mich.

... *the instrument with the* TAPE-SLIDEWIRE!



Why not have highest accuracy... if it costs no more???



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CIRCLE 59 ON READER-SERVICE CARD

editorial

Market Research

Marketing research is becoming increasingly important to instrument manufacturers because instrument marketing problems are aggravated by the competitive, transient nature of the business, plus rapid expansion of the technology. Twenty-two laboratory and industrial instrument manufacturers cooperated in this survey of marketing research practices and organization.

ALBERT W. CHAPPLE
The Perkin-Elmer Corporation

RAPID EXPANSION of instrument technology within the past two decades has created marketing problems for every instrument company, large or small, new or well established. New product developments and increasing applications for existing products also have accelerated the growth of laboratory and process control instrumentation. This survey attempted to determine the importance of marketing research to these instrument manufacturers.

Scope of Study

The survey concerns marketing-research practice among twenty-two United States manufacturers of laboratory and process control instruments. Companies employing less than 250 or more than 5000 were excluded. Larger companies compete in this market and are known to have organized marketing research groups; to compare these large corporations with manufacturers more dependent on laboratory and process control instrument products would probably distort results. Smaller firms were eliminated because it was believed that few companies employing less than 250 persons can support staff marketing-research functions.

Twenty-seven companies fitted these criteria, and twenty-two respondents provided detailed information in answer to the survey questionnaire. Combined sales volume of the twenty-two cooperating companies was estimated at $550,000,000. Laboratory and process control instruments were estimated to account for almost half this total, or $265,000,000. Questions were designed to reveal the extent to which instrument manufacturers are using marketing research to help solve marketing problems.

Survey Results

Twelve of twenty-two laboratory and process control instrument producers employ full-time marketing research specialists. In most companies, sales, marketing or planning executives or other groups also participate in marketing research activities.

Company size influences establishment of a full-time marketing research function. Nine of ten firms employing 2000 to 5000 persons sustain marketing research sections, while only three of twelve companies employing 250 to 1999 do. Except for the oldest manufacturers, company age does not directly influence staffing for marketing research. Geographical location has no bearing on existence of a marketing research group within a company.

Eight of twelve companies having marketing research organized the function within the past five years. A few have had research specialists for many years. An average of two professional (non-clerical) market analysts are engaged in instrument studies among these companies.

Most managers of marketing research report at executive levels paralleling general industry. Eight of twelve report directly to company officers or general managers. Six report to individuals responsible for sales or marketing. The most common title given the head of this function is "Manager, Marketing (or Market) Research." Although one-half of the individuals responsible for marketing research have backgrounds in both marketing *and* science or engineering, nearly as many have education and previous experience mainly in marketing alone.

Marketing Information Sources

The instrument company's field sales force is a common source of marketing information. The technical nature of this industry's products forces management to hire and train engineering and scientific specialists for many sales positions. Reliance on technically competent sales personnel is common to all save one of the companies studied.

Dealers, distributors and manufacturers' agents are important channels of distribution for certain laboratory and process control instruments. Two-thirds of the twenty-two companies use resale groups for getting market facts. Although resale organizations are an important channel for obtaining marketing facts, they are not nearly as important as company salesmen.

Advertising agencies often conduct marketing studies and surveys for *consumer* products. However, *industrial* marketing research is less frequently carried out by advertising agencies. The laboratory and process control instrument industry is no exception. None of the respondents used their agencies often for marketing information. Almost two-thirds of the manufacturers represented sometimes seek the aid of their advertising agencies for gathering market data; more than one-third never seek assistance from an agency. One smaller company has no advertising agency.

This study is based on the author's master's thesis, "Marketing Research in the Laboratory and Process Control Instrument Industry," New York University, Graduate School of Business Administration, April, 1958.

Use of Consultants

In post-war years, consultants in marketing research and management practices have multiplied. The total impact of the work of consultants within the instrument industry is unknown. Response to this survey indicates that employment of outside consultants by instrument manufacturers may be more common than generally known. One-half of the twenty-two companies use marketing or management consulting services. One company (more than 2000 workers) having full-time marketing research often utilizes consultants for market intelligence. Ten corporations indicate that marketing or management consultants are sometimes employed. One company employs marketing consultants for consumer product studies but not for industrial instruments.

Most instrument manufacturers seek no assistance from their *technical* research consultants to obtain market information. Only three of ten larger instrument makers use technical consultants, while one-half of the twelve companies employing less than 2000 people use technical sources for market data. Only one-third of the concerns having internal marketing research use technical consultants, while one-half of those firms without organized marketing research refer to this source for help in obtaining marketing knowledge.

Types of Research Conducted

All instrument companies are much concerned with forecasting sales, making new-product surveys, and analyzing sales. Almost all study sales territories, sales policies, pricing factors, market development activities, existing product lines and competition. Most firms study specific industry situations, but those with marketing research specialists available put more emphasis on industry analyses. About two-thirds conduct their own advertising studies. Few are interested in economic research. Instrument firms are less interested in the latter two marketing research activities (advertising studies and economic research) than general industry.

Acquisition Studies

Ten of twenty-two corporations conduct acquisition studies. Younger and/or larger companies appear more acquisition-minded than their opposites. Somewhat greater activity in studying potential acquisitions is shown by firms with marketing research sections.

New-Product Emphasis

New-product surveys are the most important area of marketing research for these companies, and are considered most in need of improvement. Two-thirds believe new-product studies most important, and about half pointed to this activity as most improvable. Sales forecasting and market studies also rate high in importance. Forecasting needs more improvement than market studies. Existing product studies also need improving. Analyses of sales territories are also considered an important marketing research function.

Companies making laboratory and process control instruments emphasize importance of new-product studies more than the average manufacturing concern.

The Future

Sixteen of twenty-two companies intend to expand marketing research. The other six plan to maintain about the same level of activity. Almost all firms staffed with marketing research men aim to expand their efforts. In half the cases where expansion is contemplated, respondents specified that new-product surveys would be emphasized. Six companies intend to add personnel for these and other research projects.

The Company With M-R

An instrument company with an organized marketing research function is generally larger (over 2000 employees) than one without. Less than half its sales volume comes from laboratory and process control instruments. Its marketing research department has been established for several years. Two professional market researchers and other groups within the company work on instrument marketing problems. Their activities are sometimes augmented by outside marketing or management consultants. Company salesmen are sometimes used for obtaining marketing information. Marketing research and other company personnel concentrate on new-product surveys, sales analyses and forecasting. The company is alert to acquisition possibilities. New-product surveys are the most important, and most improvable marketing research function. The company intends to expand marketing research, and to add new personnel for the job.

The Company Without M-R

The company without marketing research staff has about half its sales in laboratory and process control equipment. It generally employs fewer than 2000 workers. Marketing, sales or planning executives and departments share the marketing research burden. The company relies heavily on sales personnel for gathering market data. Internal studies, such as sales analyses, forecasting, or territorial analysis, are performed more frequently than specific market or industry evaluations. New-product studies are considered the most important marketing research activity, and the most in need of improvement. The company may or may not expand its marketing research activities.

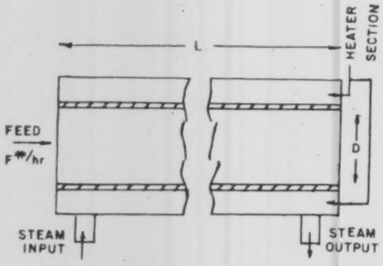
Whether formally organized for marketing research or not, all companies in this study are continually seeking answers to critical marketing questions. The instrument industry is a leading contributor to new technology. Progressive instrument firms are well aware that sound marketing research is a key factor in turning technical achievements into profitable sales.

References

1. Richard D. Crisp, *Company Practices in Marketing Research* (American Management Association, New York, 1953), Research Report No. 22.

2. *Marketing, Business and Commercial Research in Industry* (National Industrial Conference Board, Inc., New York, 1955), Studies in Business Policy No. 72.

+100
② $10^{-4} k_o$
5



Problem: To calculate the required length of a Chemical Tubular Reactor to obtain a specific material composition for a range of operating and input conditions such as input gas temperature, furnace temperature, input feed rate, tube diameter, etc.

Tubular Reactor Simulation

C. WORLEY
Electronic Associates, Inc.

Derivation of Material-Balance Equation

THE GENERAL MATERIAL-BALANCE expression for reactors is:

$$\left[\begin{array}{l}\text{Rate at}\\ \text{which}\\ \text{Reactant}\\ \text{is added}\\ \text{in feed}\\ \text{stream}\end{array}\right] - \left[\begin{array}{l}\text{Rate at}\\ \text{which}\\ \text{Reactant}\\ \text{is lost in}\\ \text{exit stream}\end{array}\right] - \left[\begin{array}{l}\text{Rate at}\\ \text{which}\\ \text{Reactant is}\\ \text{coverted in}\\ \text{reactor}\end{array}\right] = \left[\begin{array}{l}\text{Rate of Change}\\ \text{of reactant}\\ \text{in reactor}\end{array}\right]$$

Terms (1) and (2) at left represent rates of flow of the particular reactant; (3) represents rate of reaction, written for the same reactant and volume V; (4) on the right represents rate of change of reactant in reactor.

For a tubular-type reactor the mass entering a differential element dV_R is:

$$FZ_o - Fx \qquad (1)$$

where F = molal flow rate entering reaction tube; Z_o = weight fraction of reactant in feed; x = conversion (fractional conversion, dimensionless).

Mass leaving element dV_R is:

$$FZ_o - F(x + dx) \qquad (2)$$

where dx = conversion in element dV_R.

Reactant converted in element dV_R is:

$$rdV_R \qquad (3)$$

where r = rate of reaction of component A (moles/unit volume/time).

The steady-state material-balance equation requires that (2) − (1) = (3), or:

$$Fdx = rdV_R \qquad (4)$$

$$\text{But } dV_R = A_R dL \qquad (5)$$

$$\text{Thus } Fdx = rA_R dL \qquad (6)$$

Derivation of First-Order Rate Equation

$$r = kC_A \qquad (7)$$

where r = rate of reaction (moles/unit volume/time); k = specific reaction rate (1/time); C_A = concentration of component A (moles/unit volume)

The molal flow rate entering the reaction tube is F. At the point where the conversion is x, the flow rate will be:

$$N_A = F - Fx \qquad (8)$$

Total molal flow rate:

$$N_t = F(1 + x) \qquad (9)$$

For the perfect-gas law:

$$C_A = \frac{N_A}{V} = \frac{N_A}{N_t RT/P_t} = \frac{N_A P_t}{N_t RT} \qquad (10)$$

where P_T = total absolute pressure (psia); T = reaction temperature (°K); R = gas constant.

From 8 and 9:

$$C_A = \left(\frac{P_t}{RT}\right)\left(\frac{1-x}{1+x}\right) \qquad (11)$$

$$\text{From 7:} \quad r = k\left(\frac{P_t}{RT}\right)\left(\frac{1-x}{1+x}\right) \qquad (12)$$

Hence (5) becomes:

$$Fdx = \left(\frac{kA_R P_t}{RT}\right)\left(\frac{1-x}{1+x}\right) dL \qquad (13)$$

Derivation of Heat-Balance Equation

The general heat-balance equation is:

$$rdV_R(-\Delta H) - dQ_s = \sum_{i=1}^{n} M_i c_{pi} dT \qquad (14)$$

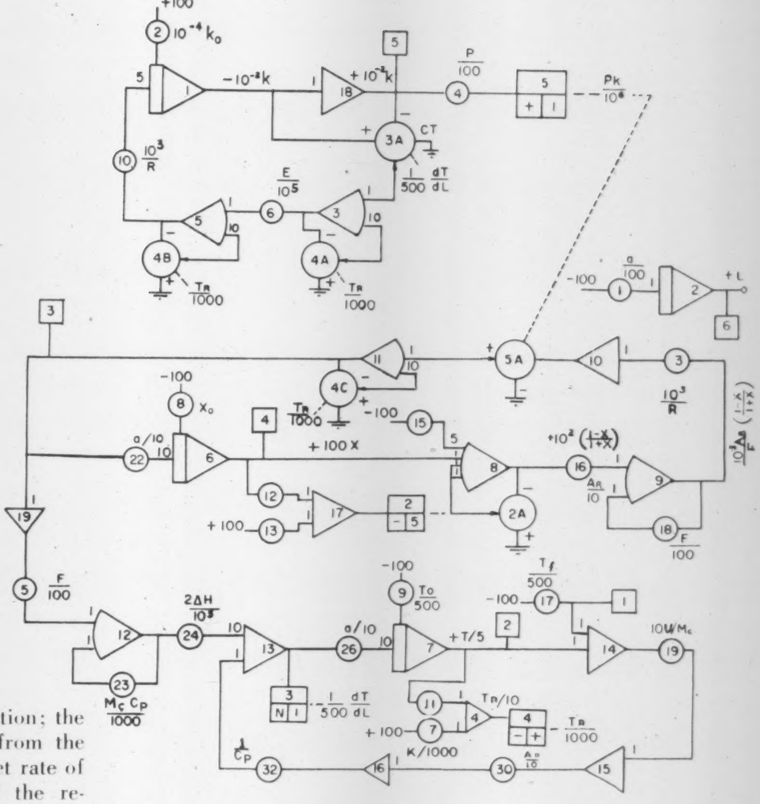
where c_{pi} = specific heat of component; the first term is the rate at which energy is evolved in the

Values of parameters used in calculation:

$R = 1543$ ft-lb/(lb-mol)(°R)
k = Specific reaction rate = min^{-1}
k_o = Initial specific reaction rate = 850 min^{-1}
P = 35 psia
F = 51 lb-mol/min
E = Energy of activation = 27,200 ft-lb/lb-mol
K = 460
$x_o = 0.002$
T_o = 80°F
A_R = Area of reactor = 5 in^2
T_f = Furnace temperature = 200°F
U = Heat transfer coefficient = 5.0 Btu/hr/ft^2/°F
M_c = Mass of reaction mixture rate = lb-mol/min = 38
c_p = Average heat capacity of reaction mixture = 25.3 Btu/lb-mol/°R
ΔH = Heat of reaction = 48,000 Btu/lb-mol.
C_A = Concentration of component A (moles/unit volume)

Calculation of Pot Settings:

1 — a/100 = 1/100 = 0.0100
2 — $10^{-4} k_o = 10^{-4}$ (850) = 0.0850
3 — $10^8/1543 = 0.6481$
4 — P/100 = 35/100 = 0.3500
5 — F/100 = 51/100 = 0.5100
6 — $E/10^5 = 27{,}200/10^5 = 0.2720$
7 — K/1000 = 460/1000 = 0.460
8 — $x_o = 0.0020$
9 — $T_o/500 = 80/500 = 0.1600$
10 — $10^8/R = 10^3/1543 = 0.6841$
11 — Constant = 0.5000
12 — Constant = 0.5000
13 — Constant = 0.5000
15 — Constant = 0.2000
16 — $A_R/10 = 5/10 = 0.5000$
17 — $T_f/500 = 200/500 = 0.4000$
18 — F/100 = 51/100 = 0.5100
19 — $10U/M_c = 10\,(5)/(38)(60) = 0.0219$
22 — a/10 = 1/10 = 0.1000
23 — $M_c\,C_p/10^3 = (38)(25.3)/10^3 = 0.9614$
24 — $2\triangle H/10^5 = (2)(48{,}000)/10^5 = 0.9600$
26 — a/10 = 1/10 = 0.1000
30 — $A_R/10 = 5/10 = 0.5000$
32 — $1/c_p = 1/25.3 = 0.0395$


+100
2
$10^{-4}k_o$
5
1
$-10^{-2}k$
1
18
$+10^{-2}k$
5
P/100
4
5
+ | 1
Pk/10⁶
3A
CT
$\frac{1}{500}\frac{dT}{dL}$
10
$\frac{10^3}{R}$
E/10⁵
6
3
5
4B
4A
T_R/1000
T_R/1000
3
-100
1
a/100
2
+L
6
11
5A
10
3
4C
T_R/1000
-100
8
x_o
4
15
$10^3/R$
$\frac{10^3 A_R}{F}\left(\frac{1-x}{1+x}\right)$
a/10
22
6
+100 X
$+10^2\left(\frac{1-x}{1+x}\right)$
16
A_R/10
9
2A
12
17
2
- | 5
+100
13
18
F/100
19
5
F/100
-100
9
T_o/500
T_f/500
-100
17
1
2ΔH/10⁵
24
12
23
$M_c C_p$/1000
13
a/10
26
7
+T/5
2
14
10U/M_c
19
3
N | 1
$\frac{1}{500}\frac{dT}{dL}$
11
T_R/10
4
4
- | +
T_R/1000
+100
7
K/1000
1/Cp
32
16
30
A_R/10
15

reactor volume dV_R as a result of heat of reaction; the second term is rate of transfer of energy from the element; and the third term is the effect of net rate of addition of energy on the temperature of the reaction mixture.

But $$dQ_s = UA_R(T-T_f)\,dL \qquad (15)$$

Hence (14) becomes:

$$-F\Delta H dx + UA_R(T-T_f)\,dL = M_c c_p dT \qquad (16)$$

The second term is positive because heat flows into the reactor.

Change in Independent Variable

Time in the computer is made proportional to L. This independent-variable change is made as follows:

Let L = at; thus dL = adt.

The equation for material balance (6) involves dx/dL. As the computer knows time only, this must be changed to dx/dt at the input of each integrator. As dx/dL = (1/a) (dx/dt), dx/dt = a (- - -).

As we wish $a>1$, we must put a/10 on the appropriate pot.

The same applies to the heat-balance equation (13) in the simulation.

Derivation of Rate Equation

$$k = A\epsilon^{-E/RT} \qquad \text{(Arrhenius Equation)}$$

where A = frequency factor; E = activation energy (dimensions depend on R and T).

We need change in specific reaction rate as a function of reactor length.

$$\text{so} \quad \frac{dk}{dL} = \frac{dk}{dT}\,\frac{dT}{dL}$$

$$\text{where} \quad \frac{dk}{dT} = -\left(\frac{AE}{R}\right)\epsilon^{-E/RT}\,\frac{dT^{-1}}{dT}$$

$$\text{But} \quad \frac{dT^{-1}}{dT} = -\frac{1}{T^2}$$

$$\text{Thus} \quad \frac{dk}{dT} = \left(\frac{AE}{RT^2}\right)\epsilon^{-E/RT}$$

$$\text{But} \quad A\epsilon^{-E/RT} = k$$

$$\text{Thus} \quad \frac{dk}{dT} = \frac{kE}{RT^2} \quad \text{and} \quad \frac{dk}{dL} = \frac{kE}{RT^2}\,\frac{dT}{dL}$$

Simulation Circuit

Amplifiers 6, 17, 8, 9, 10, and 11 (in loop) are solving material-balance equation (13).

Amplifiers 12, 13, 7, 14, 15, and 16 (in loop) are solving heat-balance equation (16).

Amplifiers 1, 18, 3 and 5 (in loop) are solving equation (18).

Amplifier 8 forms ratio $(1-x)/(1+x)$

Amplifier 2 calculates the length of the reactor; i.e., solves equation dL = adt, or $L = a\int dt$

Channel 1 records temperature of reactor walls ($T_f/5$)

Channel 2 records reaction temperature (T/5)

Channel 3 records dx/dL (100 dx/dL)

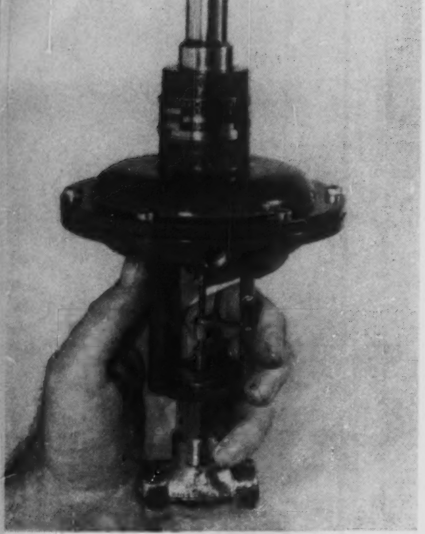
Channel 4 records conversion of feed (100 x)

Channel 5 records specific reaction rate (k/100)

Channel 6 records length of reactor (L).

Reference

1. J. M. Smith, *Chemical Engineering Kinetics*, McGraw-Hill Publishing Co.



Valves for Little Flows

A valve with a C_v of 3.00 or less is a small valve. Here is a discussion of application factors of valves with C_v from 3 down to 0.00006.

ROY HORTON
President
Research Controls, Inc.

SMALL FLOWS are best handled by little valves. Small-volume systems are common in pilot and semi-commercial plants that develop and prove new processes. If such systems are to simulate a future process, the true answers to behavior and production results require duplication in miniature; only the volume of throughput is different. The control valves in such a pilot system should be small.

A second important application is introducing additives in bulk processing. Most of today's products are complex compounds. Injected someplace along the process is a slight inhibitor, a synthetic, a coloring. Such small quantities must be metered into the process with precise control.

Inner Valve and Topworks

The heart of a valve is its inner valve. The profile and ability to vary an orifice area as a function of its stroke determines whether the process variable is changed exactly as the control signals. For example, a large "little" valve has a C_v of, say, 2.5; hence an error of 1% means 0.025 gpm (95 cc/m), an often intolerable error.

High accuracies are associated with varying an orifice in this magnitude of flow; even one tenth of a thousandth of an inch often is enormous in valves with C_v of 0.25, 0.0025 or even 0.000025. Flows are controlled that low, and lower.

Terminology

C_v = Flow coefficient; equals gallons per minute of water that flow through wide-open valve with 1-psi drop across valve.

Topworks = Mechanisms for controlling valve port.

Inner Valve = Plug used to adjust flow port.

Rangeability = Ratio of maximum to minimum *controllable* flows in a control valve; range through which the desired valve characteristic is maintained.

Application Requirements

Small diaphragm control valves for process control should operate on the same principle as their larger counterparts, be available with the same accessories, and have practically identical components. Their parts should be interchangeable. They should be connectable to fittings, pipe, and specialties of other manufacturers working to common and accepted standards. Various packing materials, including bellows seals, should be standard available accessories.

Diaphragm materials of different grade and kind should be available. Topworks should be available and interchangeable to different body assemblies. Different body patterns—globe, angle, or three-way—also should be available and interchangeable.

The inner valve must have the same control characteristics as the large ones—linear, percentage (equal percentage), and disc or on-off quick-opening type.

A smooth-surfaced plug for low flows produces the most precise and consistent results in little control valves. While they are considerably more difficult to characterize in profile than one with notches, grooves or lengthwise scratches, they behave more dependably; flow is distributed around the entire periphery of the profile rather than being restricted and concentrated.

Sizing

Sizing and selecting a little control valve follows the same procedure as for large control valves; conventional flow and C_v formulae are applicable. However, because flow of fluids through small control valves departs considerably from that associated with larger flows, the user's complete set of flow conditions should be transmitted to the low-flow control-valve manufacturer to apply empirical and non-published data. Otherwise the expected results under operating conditions may not be obtained.

Standard trim sizes obtainable in a ½" N.P.T. control valve start with a maximum C_V of 3.00. That is about the maximum which should be incorporated in a small valve; above that, more latitude of application may be had with a large-frame valve equipped with larger components.

Six trim sizes are associated with the ½" N.P.T. little control valve. Beginning with C_v of 3.00, each smaller size is rated at approximately two-thirds of C_v of the next higher value, or about one-and-one-half times the next lower:

Trim Size	C_v Value
A	3.00
B	2.00
C	1.25
D	0.80
E	0.50
F	0.32

At a C_v of 0.32 it is advisable to switch to a ¼" N.P.T. valve and topworks because larger topworks can damage the precise inner valves of the smaller capacities. The "F-size" trim above is made available in the ¼" N.P.T. valve. This one for the ¼" valve is not interchangeable into the ½" valve, however, because of different seat size.

There are a group of trims, 10 in number, scaled down in capacity from $C_v = 0.32$ in the same ratio as for the ½" valve:

Trim Size	C_v Value
F	0.32
G	0.20
H	0.13
I	0.08
J	0.05
K	0.030
L	0.020
M	0.010
N	0.006
O	0.003

A "P" Series of sizes begins with P1 with a C_v value of 0.002 and scales down in the same ratio pattern to $C_v = 0.00008$, and even smaller. All valves throttle from their maximum down to about 1% or 2% of maximum.

Rangeability

Rangeability of the small trims is about the same as for larger valves. Rangeability (the ratio between the maximum and the minimum *controllable* flow) represents the span which conforms to the characteristic lift-vs-flow curve. If the trim is represented as linear in characteristic, it should perform a linear function through the span of represented rangeability, between the lowest stated increment of lift through 100% of stroke.

The end areas of a profile are the difficult portions to keep within this definition of rangeability. Common rangeability is 50-to-1—that is, the maximum controllable flow (C_v) is 50 times the minimum controllable flow just after the plug is off the seat. This rangeability holds, particularly with a percentage plug, down through a "J-size" trim with a maximum C_v of 0.050. From there downwards an equal-percentage profile is not practical to produce.

Rangeability decreases as C_v decreases—at C_v of 0.003 rangeability has decreased to about 25-to-1. Below that it begins to settle out into a ratio of about 15-to-1, until at C_v of about 0.00012 it runs between 10-to-1 and 15-to-1. Unless at least a 10-to-1 ratio is maintained the valve is not of much value for control. Better than 10-to-1 ratio is achieved, however, even for C_V's in the neighborhood of 0.00006 and lower. Lapping a characteristic profile here requires skill.

Shut-off

Do not expect a control valve to be a block valve. A single-seated valve always has been considered good for shutting off flow; "bubble-tight", "no-leak-by", "dead-end" and such terms have been associated with single-seated valves, particularly small control valves. The expression—"there is not much flow anyway, therefore it should be easily dead-ended"—is a fallacy. These flows, at their maximum, were the "leaks" of yesterday. The leak detector is even now a quantitative measuring device of a flow. "Dead tight" in the fullest sense of the word is not possible with a control valve capable of varying flow to a pattern.

Control is the prime goal, shut-off is secondary. Any economical quick-opening, soft-seating, diaphragm valve can be placed in series to accomplish shut-off. Soft seating in combination with a low-flow throttling plug is not practical—lap for a shut-off and you ruin the characteristic profile. Any of the metallic plug-and-seat combinations for any of the C_v ratings mentioned are capable of closing flow off at least to 1% of maximum stated C_v value of that trim size.

High-Pressure Service

Component parts have to be large enough for suitable chucking in a machine tool without being crushed. Also large forces are imposed when making a joint tight in a line. This requires a body section strong enough for 4,000 to 6,000 psig at room temperature. Above that, particularly at 7,000 to 10,000 psig, a 59-, 60° cone, collar and gland connections are indicated, and these require a body machined differently. Above 10,000 psig it is advisable to use only the super-pressure-type fittings for connections.

Three-Way Action

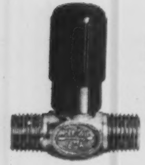
Little three-way valves available are essentially like the two-way valve. They can embody either characterized plug or on-off type that is used widely to switch the fluid flow from a line into one of two other lines. With the common port connected to the vessel, the throttling or characterized ends of the plug can mix two fluids. Each end of the characterized plugs can be of different C_v, affording a base ratio of the mix. An example is ratioing water and steam through the two controllable ports into the common port for temperature control.

Accessories available with large control valves also are provided for small control valves—including angle, offset, three-way, and jacketed bodies, packless stem seals, cooling fins and extended bonnets, handwheel operators, lubricated packing glands, alarm limit switches, special plug characteristics, pressure-balanced topworks, valve positioners, etc.

A valve is said to be of the needle type if the plug

largest demand; ¼" is also the size most in demand

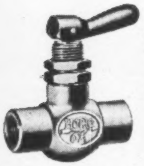
Bar Stock Valves to handle high pressures



Packless Valves to resist corrosion, hold high vacuum

Metering Valves to throttle down to a trickle

Check Valves to control one-way flow



Toggle Valves to flip on-off quickly

Small Valves for Instrumentation

Small valves are those in sizes from 1/8" to 1" pipe. Types include stop cock, plug, toggle, gate, globe, needle, needle globe, pressure reducing, straight and angle. Here are basic application and selection factors.

DONALD SALMON
Hoke, Inc.

INSTRUMENT ENGINEERS are notoriously uninterested when the subject of small valves is brought up, preferring subjects like frequency response, data handling, transducers, etc. However, many small headaches are caused by neglect of small valves, including system leaks, frozen stems, insufficient flow capacity, poor throttling, etc.

Table 1 presents small-valve terminology describing function and design characteristics.

Stop Valves

Stop valves are designed primarily for shut-off; the basic types are the *stop cock* and its variation, the *plug valve*. Both of these types are adapted readily to multiport construction for three and four-way service. Because of their simplicity, these valves are preferred where maintenance problems do not arise and ease of operation is not a fundamental requirement.

Table 1—Small-Valve Terminology and Types

I. Functional types
  - A. Stop valves
    - 1. Plug valves and cocks
    - 2. Toggle valves
  - B. Throttling Valves
    - 1. Globe valves
    - 2. Needle valves
      - a. Metering
      - b. General purpose
  - C. Pressure reducing valves
    - 1. Regulators
  - D. Uni-directional valves
    - 1. Check valves
  - E. Pressure relief valves

II. Design characteristics
  - A. Bonnet types
    - 1. Union
    - 2. Screwed
    - 3. Integral
  - B. Body types
    - 1. Forged
    - 2. Bar stock
    - 3. Cast
  - C. Stem seal
    - 1. Packing
    - 2. O-Ring
    - 3. Packless
  - D. Connections
    - 1. Pipe
    - 2. Tubing
    - 3. Welded
    - 4. Solder
  - E. Materials
    - 1. Common
    - 2. Corrosion resistant
    - 3. Plastic

The tendency of plug valves and stop cocks to freeze in position in service is overcome by lubricating the plug or by allowing a slight vertical motion of the plug to unseat it. These requirements tend to eliminate plug valves from consideration in corrosive applications or where absolutely tight shut off is required.

The *toggle valve* is a newer development designed to provide rapid action and tight shutoff at the seat, which it achieves by using a plastic or synthetic rubber seating surface.

The *gate valve* is used widely in larger sizes for shutoff purposes where obstruction of process lines is undesirable.

Throttling Valves

Throttling valves includes those valves which contain an orifice into which a disc fits so that the fluid flow can be throttled by reducing the orifice aperture. Normally, this type of valve offers more resistance to flow than a plug or gate valve.

The *globe valve*, either with flat disc or conical disc, is used widely as a general-purpose valve for instrument air, over a wide range of pressures and temperatures for both shutoff and throttling service, except where full flow capacity of the line is a basic requirement.

Globe valves imply a straight-through pattern of flow, although in going through the valve the fluid must make two 90° direction changes. The angle valve has the same throttling characteristics but offers less obstruction to flow, because the fluid changes direction only once.

The *needle valve* is a variation of the standard globe valve. The orifice is made smaller in size and the shutoff plug is made long and narrow to permit close throttling.

A valve is said to be of the needle type if the plug is conical and the portion of the plug extending below the point of shutoff is sufficiently long for throttling control. A parabolic or similar curved plug surface sometimes is encountered—also a cylindrical surface with widening V-shaped notch.

The term "*needle globe valve*" is a needle valve whose main application is for on-off service and in which little if any flow control is required.

Although it is easy to understand the need for true needle valves to throttle or control fluids flows, it may not be so easy to see the need for globe-type needle valves. One main reason for the existence of these globe-type needle valves is that they are particularly adapted for economical manufacture from drawn rod (bar stock) or forgings. Because they are made of these materials instead of castings, they are often stronger and nearly always more suitable for higher pressures than the usual types of gate and globe valves. Needle-type globe valves made of bar stock or forgings can be used with pressures above 2000 psi. This eliminates the necessity for stocking various pressure-rating cast valves—125 psi, 300 psi, 600 psi, etc. because one needle-globe valve can do for all three pressure ratings.

Bar-stock needle-type globe valves can be used instead of gate or globe valves wherever full flow capacity of the pipeline in which they are installed is not required. There are many applications where gate or globe valves, still being used from force of habit or because of prejudice against the smaller external appearance of the needle-globe type, are not actually needed because the pipe in which they are installed is only required to convey a small percentage of the total flow it is capable of passing. The needle-globe valve compares favorably economically and in many cases is lower in cost.

Specifying the Valve

The important points to consider in specifying these valves for instrument applications are listed below. Pressure regulators and relief valves are omitted from the list because they belong to the automatic valve category. These are the important specifications for small hand valves of the globe, toggle, needle or plug variety:

(1) Size of valve.
(2) Materials and construction (casting, forging, bar stock; brass, steel, etc.).
(3) Pressure rating.
(4) Temperature rating.
(5) Ability to throttle (needle valves).
(6) Speed of operation.
(7) Freedom from leaks.
(8) Manner of mounting.
(9) Pattern (angle, straight, etc.).

(1) Small valves are classed generally in sizes 1/8" pipe through 1" pipe. A comparable range of sizes is available for tubing, but the variety of choice in tubing patterns is not quite as wide as in pipe styles. In the pipe sizes the majority of sales take place in sizes 1/8" through 1/2". Of these four sizes, 1/4" pipe is in largest demand; 1/4" is also the size most in demand in tubing.

(2) Selection of suitable construction materials depends on the operating conditions.

(3) Small valves are available from types suitable for high-vacuum service to those for pressures in excess of 30,000 psi.

(4) Temperatures at which small valves are used range from liquid nitrogen (or lower) to 1000° F and up.

(5) The throttling ability of a needle valve almost always depends on four factors—(a) The size of the seat orifice, (b) the included angle on the normally conical stem point; (c) the pitch of the stem thread; (d) the length of the conical stem tip below the shutoff orifice. (In this case the tip must emerge from orifice over length mentioned.) One of the best methods of evaluating the flow control of a needle valve is to examine curves plotted to show the relation between fluid flow and number of turns of the stem for a number of different pressure differentials across the valve. Some manufacturers publish such curves or similar information for the guidance of prospective users. C_v factors (if available) indicate the capacity of the valve when wide open.

(6) If the valve is required for on-off (stop) service there are two principal types of mechanisms in use for quick operation of small valves. One is a cam (or toggle) and the other is a stem thread having a rapid rise. Of the two, the cam is the faster acting, but when used deprives the valve of the right to be termed "needle type." Cam-type valves usually have flat discs or seats. The stem with steep pitch or rise has a measure of flow control remaining and is used where fast operation or ready identification of the open or closed position is wanted. Typical use for such a valve is to replace the ground-joint stop cocks traditionally used in laboratories for air, water, etc.

(7) The degree to which a small valve is free of leaks depends on the care with which it is manufactured. However, assuming a high quality in manufacturing, the design of the packing system and seat combination in a needle valve largely determines how leak tight it is.

The degree of seat tightness in metal-to-metal valve seats depends on the concentricity between the plug and the usually integral seat at the moment they touch each other. Another important point is finish on seat and plug. For repeated and sure seat tightness the best choice is a rubber or plastic disc closing against a metal seat. When plastic or rubber is out of the question, strict observance of the first two points in combination with either, or preferably both, of the following measures will come closest to yielding the near perfection of a plastic or rubber seat: (a) Design a non-rotating plug for closing against the seat; (b) use a device that limits the closing force applied to the stem to that required to shut off tight and no more.

(8) Small valves are supported usually by the pipe or tubing to which they are connected. However, panel-mounting valves are available.

(9) There are basically two types of patterns available in small valves—straight and angle. A tee type is sometimes available as a specialty item.

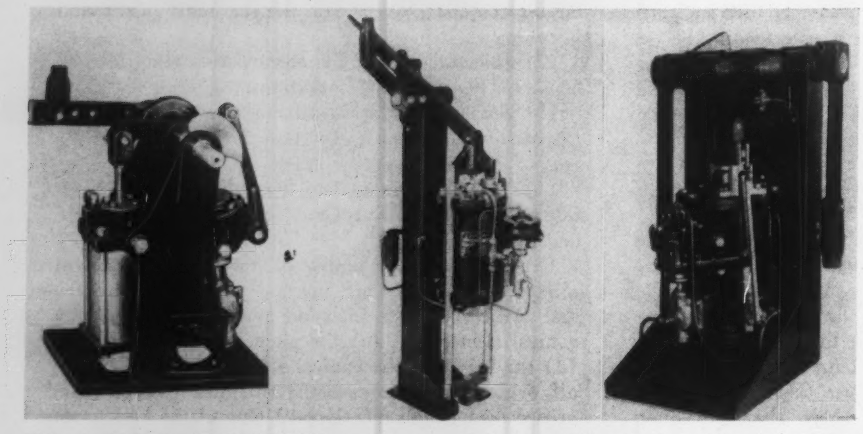


FIG. 1. PNEUMATIC POWER positioners. A is 4" x 5" unit, B is 5" x 10", C is 6" x 10".

Response of Pneumatic Power

Response of pneumatic valve actuators of several types was reported in the March issue. Here is response data of a line of pneumatic power positioners.

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Chief Engineer
Hagan Chemical & Controls

FIG. 1 shows a 4″ x 5″ (4″-dia cylinder with 5″ stroke) torque-type pneumatic power positioner, with a recommended maximum operating air supply pressure of 100 psig, recommended minimum of 45 psig, based on 100-psig air supply pressure. Maximum recommended control torque is 240 lb-ft at 100-psig supply.

The positioning principle is shown in Fig. 2. The input signal pressure on top of diaphragm is force balanced against a force developed by the piston acting against the spring. This takes place in two steps:

1. Incoming signal operates four-way pilot valve by moving diaphragm.
2. Resulting motion of piston is returned to the spring through the cam until pilot valve and diaphragm return to neutral, at which point the two forces are balanced.

The cam shape determines the relation between input signal and lever position. Cam can be shaped in the field to produce any relationship; standard cam produces straight-line relationship.

Fig. 3 is the frequency response of the 4″ x 5″ receiving regulator for three different signal amplitudes—1, 2 and 3 psi peak-to-peak. Solid lines show attenuations; broken lines show phase shifts.

5″ x 10″

Hagan's 5″ x 10″ (5″-dia. 10″ stroke) torque-type pneumatic power positioner (Fig. 1B) has the same

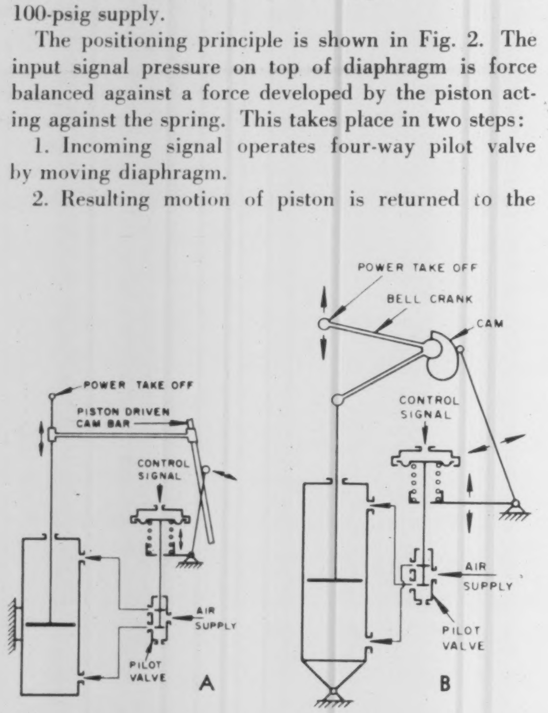


FIG. 2. PRINCIPLE OF operation. A is principle of 4" x 5" unit; B is principle of larger units.

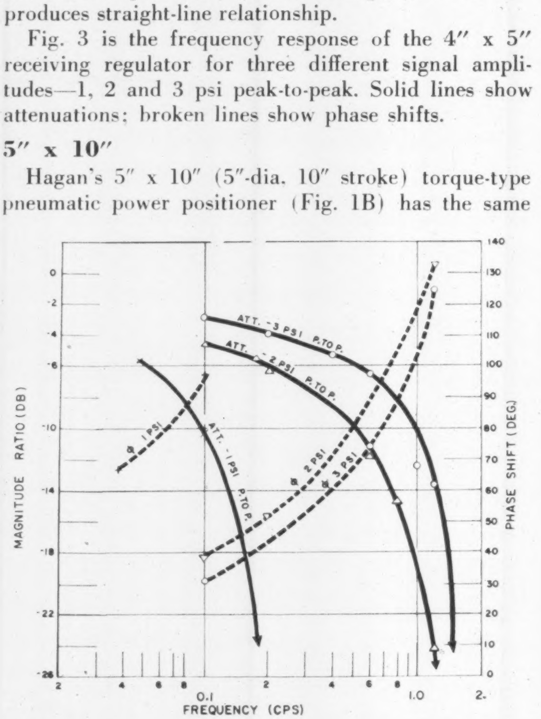


FIG. 3. RESPONSE OF 4" x 5" unit for signals of 1, 2 and 3 psi peak-to-peak.

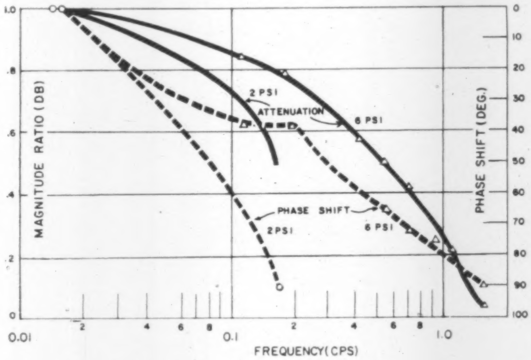


FIG. 4. RESPONSE OF 5" x 10" unit for peak-to-peak change of 2 and 6 psi.

Positioners

recommended operating air supply pressure as the 4″ x 5″ positioner. Maximum recommended control torque is 850 lb-ft (based on 100-psig supply pressure.)

The positioning principle is only slightly different than that of the 4″ x 5″ positioner (Fig. 2B). A cam bar is used rather than a cam. Again the cam bar shape determines the relation between input signal and lever position. The cam bar can be shaped in the field to produce any relationship; the standard cam bar produces a straight-line relationship.

Fig. 4 shows the response for peak-to-peak change of 2 and 6 psi.

6″ x 10″

The 6″ x 10″ torque-type pneumatic power positioner (Fig. 1C) has a recommended operating air supply pressure 45 psig to 100 psig. Operation principle is the same as that of the 5″ x 10″; the maximum recommended control torque is 1050 lb-ft (based on 100-psig air supply pressure). No-load full-stroke time in 3.0 seconds.

Response is shown in Fig. 5 for 2 and 6 psi peak-to-peak signals.

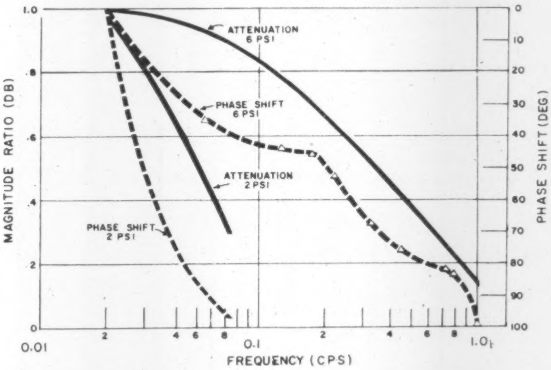


FIG. 5. RESPONSE OF 6" x 10" unit, Sinusoidal peak-to-peak change of 6 psi (10%) and 2 psi.

N B S Vibration-Pickup Test-Fee Schedule

a. This applies to the calibration of displacement, velocity, and acceleration types of vibration pickups weighing up to 2 pounds.

b. In the case of a piezoelectric acceleration pickup, the preamplifier, the power supply if other than batteries, and the connecting cables should accompany the pickup.

c. For each calibration point in excess of the number specified in the following items, an additional fee equal to the average fee per point is charged.

Item	Description	Fee
206.001a	Static calibration on a tilting support in the earth's gravitational field of accelerations up to lg, the acceleration of gravity, with an error not greater than 0.004g. Calibration for 10 different applied accelerations	$ 66.00
206.001b	Static calibration on a centrifuge at 3 different applied accelerations up to 10g for not more than two orientations with an estimated error not greater than 1 percent of the applied acceleration. (6 calibration points)	40.00
206.001c	Dynamic calibration in the frequency range from 15 cps to 2000 cps at accelerations up to 10g. The pickup is subjected to sinusoidal motion on an electrodynamic vibration standard previously calibrated by the reciprocity method. The estimated errors of the applied accelerations do not exceed 1 percent for frequencies up to 900 cps and 2 percent above 900 cps. The magnitude and phase angle of the calibration factor are determined unless a pickup is calibrated with a vibration indicator or recorder as a unit. In such cases only the indicated displacements, velocities and accelerations together with the corresponding applied displacements, velocities and accelerations are given. Calibration for 3 different accelerations at 10 different frequencies (30 calibration points)	$200.00
206.001z	For special tests not covered by the above schedule, such as dynamic calibrations of pickups weighing more than 2 pounds, calibrations of small light-weight piezoelectric ceramic pickups over an extended frequency range up to 20,000 cps or calibrations at higher accelerations, fees will be charged dependent on the nature of the test.	

From *Federal Register* September 25, 1958—Volume 23, Number 188, Mechanics Division, 206.001, Vibration pickups.

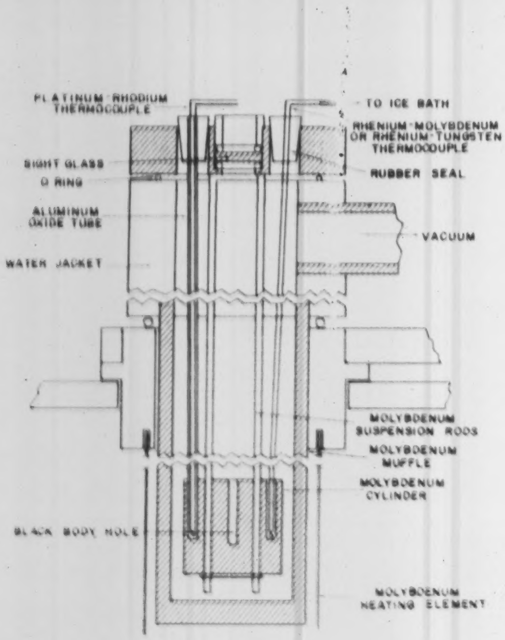

PLATINUM-RHODIUM THERMOCOUPLE
TO ICE BATH
RHENIUM-MOLYBDENUM OR RHENIUM-TUNGSTEN THERMOCOUPLE
SIGHT GLASS
O RING
RUBBER SEAL
ALUMINUM OXIDE TUBE
VACUUM
WATER JACKET
MOLYBDENUM SUSPENSION RODS
MOLYBDENUM MUFFLE
MOLYBDENUM CYLINDER
BLACK BODY HOLE
MOLYBDENUM HEATING ELEMENT

FIG. 1. **THERMOCOUPLE** calibration apparatus.

Calibration of

J. C. LACHMAN

General Electric Co.
Aircraft Nuclear Propulsion Department

ACCELERATED PROGRAMS in high-temperature materials research have increased the need for a thermocouple to measure temperatures to at least 4000°F in vacuum or hydrogen and inert atmospheres. Platinum thermocouples, which are useful for temperatures to about 2800°F, are unstable in hydrogen and are generally satisfactory only in oxidizing atmospheres. Chromel-Alumel thermocouples have a temperature limitation of about 2000°F. Tungsten-molybdenum and tungsten iridium thermocouples are of little interest because the tungsten-molybdenum combination has a low thermal emf, while iridium is brittle and scarce.

Rhenium, which has strength and ductility, was suggested as a replacement for rhodium in platinum-rhodium thermocouples nearly thirty years ago, and a limited amount of work has been reported in European literature. Recently, investigations of rhenium have been conducted at Battelle Memorial Institute under the auspices of the United States Air Force.* As a result of this work, rhenium combined with platinum was found to be a promising thermocouple material for limited temperature applications. Furthermore, it was found that rhenium-tungsten or rhenium-molybdenum thermocouples were potentially useful at high temperatures.

Thermocouples composed of these materials were found to have the following advantages:**

1. High thermoelectric potential.

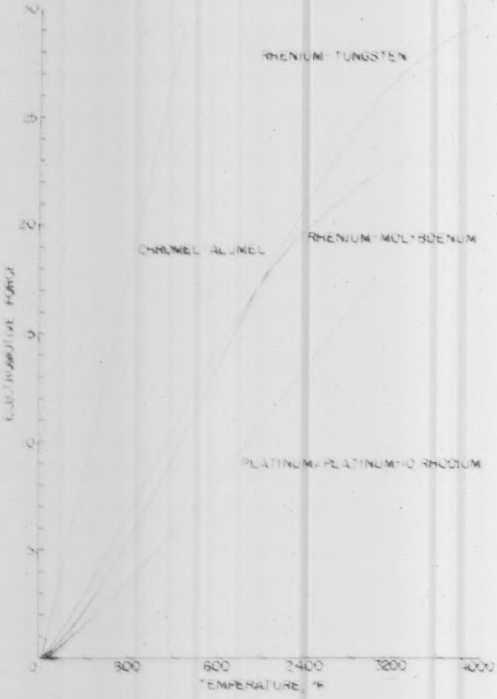
2. High thermoelectric power (millivolts per degree).

3. High melting point of all components.

4. Chemical stability in neutral or reducing atmospheres.

5. Ductility (for rhenium or rhenium-alloy legs of thermocouples) after temperature cycling.

FIG. 2. **THERMAL EMF** (mv) of rhenium-molybdenum, rhenium-tungsten and standard thermocouples.



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*WADC Technical Report 56-319, "A Survey of the Literature on Rhenium," C. T. Sims, et. al., Battelle Memorial Institute, ASTIA Document No. AD110596, June, 1956

**Ibid

Thermocouples to 4000° F

Rhenium-molybdenum and rhenium-tungsten thermocouples have been calibrated to 4000°F. They have seen hundreds of hours of service, been thermal cycled many times, and yet retained accurate calibration for high-temperature measurements.

Experimental Procedure

A series of calibration experiments conducted at General Electric aimed at the calibration of rhenium-molybdenum and rhenium-tungsten thermocouples with sufficient accuracy to permit their use in instrumentation. Experiments also were conducted to determine the effect, if any, of continuous temperature cycling in neutral or reducing atmospheres.

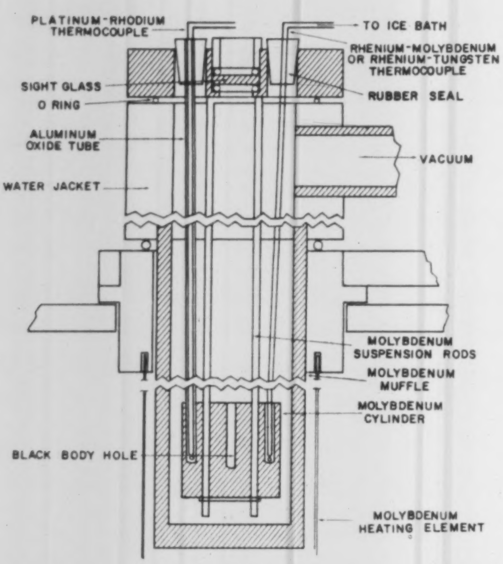
Rhenium-molybdenum and rhenium-tungsten thermocouples were prepared by joining the component wires by inert arc-welding. Platinum/platinum-10 rhodium and chromel-alumel thermocouples were also prepared and calibrated as standards. Double-bore beryllium-oxide refractory insulators were used for that portion of the thermocouples in the hottest zone of the furnace because commercial aluminum oxide has temperature limitations of about 3200°F. The sources, cost and description of the various items are shown in Table 1.

Thermocouple calibrations were conducted in high-temperature research furnaces (Fig. 1). The junctions of all thermocouples were inserted into holes in a constant-temperature molybdenum cylinder suspended in the hot zone of the vacuum furnace by molybdenum rods. The thermocouple wires were brought out through rubber seals in the muffle cover and led to an ice bath where cold junctions were maintained at 32°F.

In the first set of experiments, a standardized platinum/platinum-10 rhodium thermocouple was installed in a similar manner to measure reference temperatures, but it was found that this type of thermocouple did not retain its accuracy in vacuum. Therefore, the apparatus was modified to permit heating of the platinum thermocouple in a normal atmosphere while the rhenium thermocouples were heated in vacuum. The closed end of a heavy-wall aluminum oxide protection tube was inserted into the molybdenum cylinder and a vacuum seal effected by a rubber stopper in the muffle

TABLE I—SOURCES AND COST OF HIGH-TEMPERATURE THERMOCOUPLE MATERIALS

Material	Description	Source	Approximate Cost
Platinum or Platinum- Rhodium	0.025" diam. Wire	American Platinum Works	$8.00-9.00/ft.
High-purity Rhenium	0.025"-0.030" diam. wire, cold drawn and annealed	Chase Brass and Copper Company	$7.80/ft.
High-purity Molybdenum	0.025" diam. wire	General Electric Lamp, Wire and Phosphorous Department or North American Phillips Company	$15.00/500 ft.
High-purity Tungsten	0.025" diam. wire	General Electric Lamp, Wire and Phosphorous Department or North American Phillips Company	$45.00/500 ft.
High-temperature Al_2O_3 Thermocouple Sleeving	98.56% fine grain double bore 5/32" O.D. x 20" long	Norton Company	$2.50 each
Beryllium-Oxide Thermocouple Sleeving	High purity, double bore, 5/32" diameter in random lengths	Brush Beryllium Company	$15.00/ft.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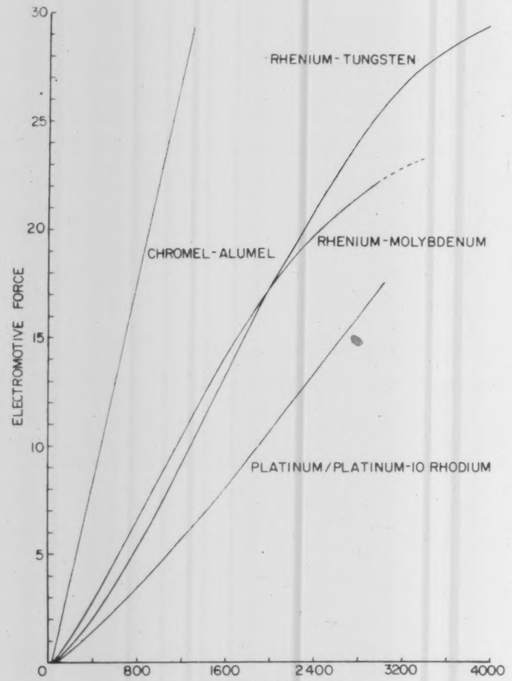

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Thermocouples composed of these materials were found to have the following advantages:[**]

1. **High thermoelectric potential.**
2. **High thermoelectric power (millivolts per degree).**
3. **High melting point of all components.**
4. **Chemical stability in neutral or reducing atmospheres.**
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cover. This arrangement proved adequate for isolating the platinum-rhodium reference thermocouple from the furnace atmosphere, and the aluminum oxide tube was satisfactory for temperatures up to 3200°F.

A vacuum of 5 microns was maintained in the furnace muffle while the temperature *versus* emf relationship for rhenium-molybdenum and rhenium-tungsten thermocouples was obtained within the limitations of the standard reference thermocouples. A high-precision Minneapolis-Honeywell Rubicon potentiometer was used to measure emf. A possible source of error due to induced emf from the furnace heating element was eliminated by adequate filtering of the thermocouple input to the potentiometer. The accuracy of the reference temperatures was substantiated by recalibration of the standard platinum-rhodium and chromel-alumel thermocouples at the conclusion of the experiments. Above the range of platinum-rhodium thermocouples (3000°F), the standard couple was removed and temperatures were measured with a standardized Pyro Micro-Optical pyrometer by sighting on a hole in the molybdenum cylinder. This optical method also was used to make frequent checks of the reference thermocouple at lower temperatures.

After several preliminary calibration runs, new rhenium-molybdenum and rhenium-tungsten thermocouples were installed in the molybdenum cylinder adjacent to the original thermocouples. The thermal stability of rhenium thermocouples was established by comparing the emf of these thermocouples with the emf of the one that had been temperature-cycled several times. Similar calibration experiments were conducted using both hydrogen and inert gases for the furnace atmosphere for comparison with the results obtained in vacuum.

Results

1. Rhenium thermocouples have been established as reliable for measuring temperatures to 4000°F in vacuum, hydrogen, or inert atmospheres.
2. Rhenium-tungsten thermocouples have been calibrated to 4000°F with an accuracy of 0.1 millivolt.
3. Rhenium-molybdenum thermocouples are useful only to 3200°F because of limitations in thermoelectric power.

Both rhenium-molybdenum and rhenium-tungsten thermocouples produce a relatively high emf and exhibit good sensitivity to temperature change. Calibration curves for these thermocouples are shown in Fig. 2 in comparison with standard chromel-alumel and platinum-rhodium thermocouples.

These emf values were found to be higher than the earlier values reported by Battelle Memorial Institute, although the calibration curves are of similar slope. As shown in Fig. 2, the emf generated by rhenium-molybdenum thermocouples levels off at about 3400°F. On the other hand, rhenium-tungsten thermocouples continue to show an increasing emf with increasing temperature even beyond 4000°F.

Repeated calibrations and extensive service applications show that temperature cycling has no effect on the thermoelectric properties. In addition, emf values for the rhenium-molybdenum or rhenium-tungsten thermocouple that were cycled in a hydrogen and inert gas atmospheres are in close agreement with results obtained for the thermocouples cycled in vacuum. The rhenium leg of all experimental thermocouples remained ductile after temperature cycling. The tungsten or molybdenum legs became brittle; this may present some application problems.

As a result of extensive uses of rhenium-molybdenum thermocouples and of subsequent calibration of a considerable number of these thermocouples, accurate emf values as a function of temperature were established to 3200°F. Studies will be continued in which similar data will be presented both for rhenium-molybdenum and rhenium-tungsten thermocouples at higher temperatures. Calibrations to 5000°F for rhenium-tungsten thermocouples will also be conducted.

In addition, a series of workable alloys of rhenium-molybdenum and rhenium-tungsten is being fabricated into 0.025-inch-diameter wire. This alloy wire in combination with unalloyed rhenium, molybdenum, or tungsten will be used in developmental thermocouples. If one of these alloy combinations proves to have favorable thermoelectric properties, a ductile thermocouple will be available.

Applications

These thermocouples are (1) useful in temperature ranges beyond the capability of existing thermocouples, (2) stable in non-oxidizing atmospheres at temperatures where the more common thermocouples lose their accuracy, (3) stable with respect to thermoelectric properties and calibration after thermal cycling, (4) not subject to deteriorations which would limit operational life, and (5) less expensive than the noble metal thermocouples.

For applications requiring the use of these thermocouples in high-temperature air, sealed assemblies have been fabricated successfully and operated up to 2400°F for long periods. In order for rhenium-base thermocouples to be accepted in industry, standards of purity for wire components should be established so that the temperature-emf relationships are reproducible. Instrumentation should be made available which will permit direct temperature readings, and compensated lead wires and connectors should be developed, especially for the rhenium-molybdenum combination.

TEMPERATURE-MILLIVOLT EQUIVALENTS REFERENCE JUNCTION AT 32°F

Deg. F.	Rhenium Tungsten	Rhenium Molybdenum
0		
100	0.245	0.345
200	0.704	0.999
300	1.247	1.760
400	1.913	2.598
500	2.669	3.510
600	3.468	4.453
700	4.320	5.434
800	5.238	6.442
900	6.181	7.433
1000	7.153	8.420
1100	8.172	9.428
1200	9.188	10.409
1300	10.204	11.362
1400	11.222	12.312
1500	12.248	13.256
1600	13.262	14.116
1700	14.267	14.971
1800	15.245	15.765
1900	16.203	16.536
2000	17.166	17.263
2100	18.087	17.967
2200	18.990	18.587
2300	19.868	19.169
2400	20.723	19.703
2500	21.560	20.198
2600	22.381	20.688
2700	23.181	21.122
2800	23.956	21.538
2900	24.698	21.894
3000	25.409	
3100	26.060	
3200	26.645	
3300	27.140	
3400	27.582	
3500	27.976	
3600	28.317	
3700	28.626	
3800	28.923	
3900	29.214	
4000	29.467	

Digital Printers

Additions to the digital printer survey in the May issue

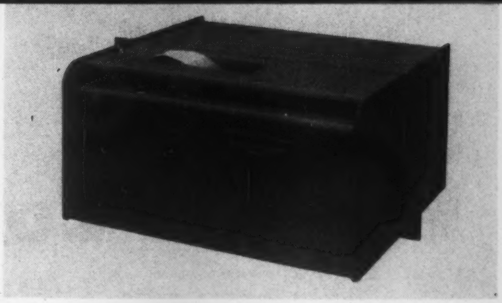


FIG. 1. Beckmen/Berkeley Model 1452

Beckman/Berkeley

The Model 1452 Digital Recorder can be coupled directly to a Berkeley electronic counting device such as Events-Per-Unit-Time Meters, Time Interval Meters, Electronic Counters and Nuclear Scalers which have a 4-line binary code available from each decade. (Most Berkeley counting equipment now in the field can be adapted for such operation.) The recorder prints sequentially (in Arabic numerals on a standard adding machine tape) the total count accumulated by the basic instrument during each of its counting periods. The Model 1452 is used for long-term stability checks, recording of transients, or for making a permanent printed record in digital control systems.

Standard recording and indicating capacity is 7 digits—can be wired for 8 digits. Maximum cycling rate is 1 printout every 0.90 second for a 7-digit line. Folded adding machine tape can be employed.

The Model 1452 consists of a stepping switch, a relay matrix, control and interlock relays, a solenoid operated adding machine and a power supply. The 4-lined coded information is connected directly to the stepping switch in the Digital Recorder. The relay matrix is so designed that an actuating voltage will be applied to the same digit of the printer as is shown visually on the Decimal Counting Unit of the basic instrument. When all Decimal Counting Units have been scanned, a print command is given to the adding machine.

FIG. 2. TelAutograph Olivetti T2CN.

TelAutograph Olivetti

TelAutograph offers the Olivetti (European made) teletypewriter line, including T2CN Page Teletypewriter for both sending and receiving (illustrated), the T2CR for page receiving, the T2PF Tape Reperforator which fits any Model T2, the T2TA Automatic Tape Transmitter, and the T2PS Printing Reperforator for sending and receiving. All are based on start-stop telegraphy 5-channel punch-tape based on CCIT standards.

Maximum speed is 75 words per minute. Features include two-color printing (incoming messages in black, outgoing in red); either standard 4-tier typewriter keyboard or teletype 3-tier; prints and punches simultaneously; prints between feed holes on punch tape; automatic answer-back; keyboard lock at end of carriage run; operates on all d-c phantom and multiple-frequency carrier systems and telephone facilities.

FIG. 3. Benson-Lehner Electrotyper Model C.

Benson-Lehner Electrotyper and Electroplotters

The Electrotyper Model C (illustrated) consists of an IBM electric typewriter, modified for use in conjunction with Benson-Lehner serial output equipment —Oscars, Boscars, and Decimal Converters, and a wide variety of shaft digitizers and other special program units.

Features include: (a) Automatic control of key numerals (1, 2, 3, 4, 5, 6, 7, 8, 9, and 0), minus sign, decimal point, tabulator, carriage return key, and a modified space key. (b) All keys are solenoid operated to enable remote electrical operation. (c) Actuating solenoids operate on 90 vdc at 0.3 amperes. (d) Maximum printing speed of 10 characters per second.

Also offered are Benson-Lehner Electroplotters which can print up to 13 symbols on any x-y graphical recorder at a rate of about 50 points per minute, or 15-20 lines per minute.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

GRINDING-MILL CONTROL SYSTEM INCREASES MILL OUTPUT BY 75 BARRELS PER DAY

In the highly-automated plant of Louisville Cement Co. at Speed, Indiana, a closed-circuit dry grinding process is used in which oversize particles are separated by air and recirculated. The ball-type grinding mills pulverize both the raw materials (cement, rock and shale), and the clinker from the kilns which produce finished cement. Fineness of grinding must be controlled carefully at both production stages to assure desired product properties such as time of setting, strength, and composition. Instrumentation of one ball mill is shown. The ball mill feeds two discharge elevators, each feeding a separator.

To maintain optimum grinding rates, the electric load on the motors operating the mill discharge elevators bears a direct relation to mill loading and, therefore, to grinding efficiency. This load is measured and used to control the speed of the belt feeding the ball mill.

The basic instrumentation consists of thermal converters (A) as load-sensing devices, and a Speedmax-H electronic recorder-controller which develops a signal proportional to the load measurement. As each ball mill has a dual set of elevators, a thermal converter is used on each; the electrical measuring circuit is arranged so that either converter can be connected to the Speedomax instrument, or both converter outputs can be averaged.

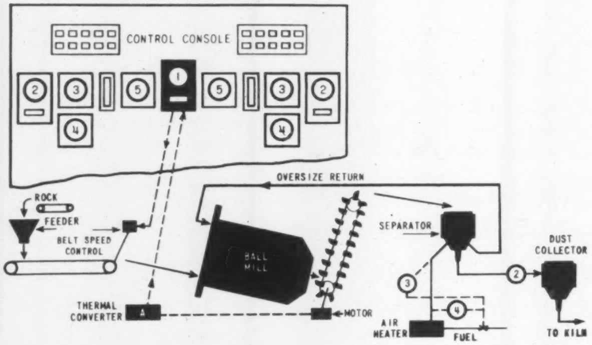
The controller regulates the speed of the feed-conveyor motor through a motor-operated drive unit. It has three-action P.A.T. (position-adjusting-type) electric control which includes proportioning, rate, and reset actions to maintain close automatic control at the desired grinding rate.

The instrumentation console for one of the two ball mills is shown. It includes (numbers refer to illustration):

1. Grinding-mill load recorder-controller, as described.

2. Separator-air discharge temperature recorder-controllers, one on each separator. These are thermocouple-actuated (Iron-Constantan) Speedomax-H units that control the fuel to the air heater. Mode of control is proportional plus reset plus rate.

3. Separator-intake air temperature recorders, also thermocouple-actuated (Iron-Constantan) Speedomax H, with alarm switches to shut off the fuel to the heaters in event the separator-intake air temperature exceeds a preset limit.



4. Air-heater discharge temperature recorders, thermocouple-actuated (Chromel-Alumel) Speedomax H, with alarm switches to shut off the fuel to heaters in event the air-heater discharge temperature exceeds a preset limit.

5. Cement, rock and shale feed-rate recorders (Speedomax H) which measure the rate of feed of the cement, rock and shale by means of tachometers on conveyors. Totalizing digital indicators on the console show the total amount of feed of each element.

6. A bank of panel alarm lights indicates improper solids flow throughout the plant.

7. Ammeters on panel indicate various currents and detect overloads.

8. Solids level indicators on panel show levels of stone and shale in silos.

9. Combustion safeguards to protect air heaters.

10. Speedomax 16-point recorder to plot various bearing temperatures on mill, feed journals and air separators.

Source: Leeds & Northrup Co., Philadelphia, Pa.

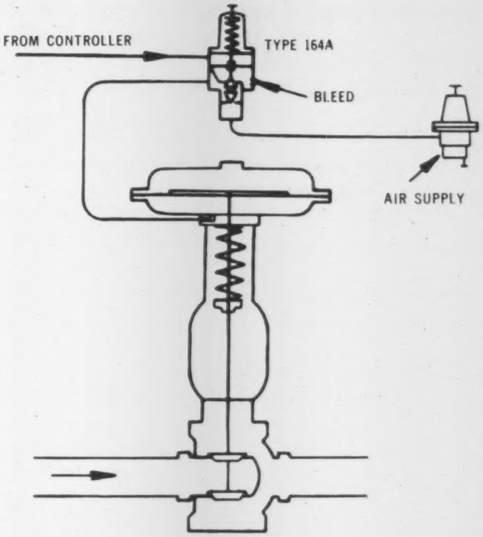
SAFETY SHUT-OFF VALVE IS ACTUATED BY SIMPLE 3-WAY VALVE

Wherever a safety shut off is required when the control signal from a controller falls below a predetermined value, a simple three-way diaphragm valve affords a convenient means for handling the situation.

Under normal conditions an air pressure from a simple regulator (Type 67FR) reaches the underside of the line valve, holding it open. The 3-way valve is also held open by the pneumatic signal from the remote controller.

When the signal from the remote controller falls below a preset minimum, however, the 3-way valve closes the port between the air supply and the line valve, and also bleeds the underside of the line valve to atmosphere. The spring in the line valve now closes the line valve. Valve will reopen when signal from the controller rises above the preset minimum.

Source: Fisher Governor Co., Marshalltown, Iowa.


FROM CONTROLLER
TYPE 164A
BLEED
AIR SUPPLY

BLENDING STYRENE WITH BUTADIENE BY REFRACTOMETER

A process refractometer has been used successfully in the closed-loop control of a butadiene-styrene blended feed to a continuous reactor train in a co-polymer operation. The ratio is about 70-30 (butadiene-styrene) weight percent, according to recipes.

The butadiene set point is set manually, and the styrene is ratioed to the butadiene flow by the ratio controller. The ratio controller is in turn controlled by the analyzer, which receives its pneumatic controlling signal from the refractometer via an electric-to-pneumatic converter.

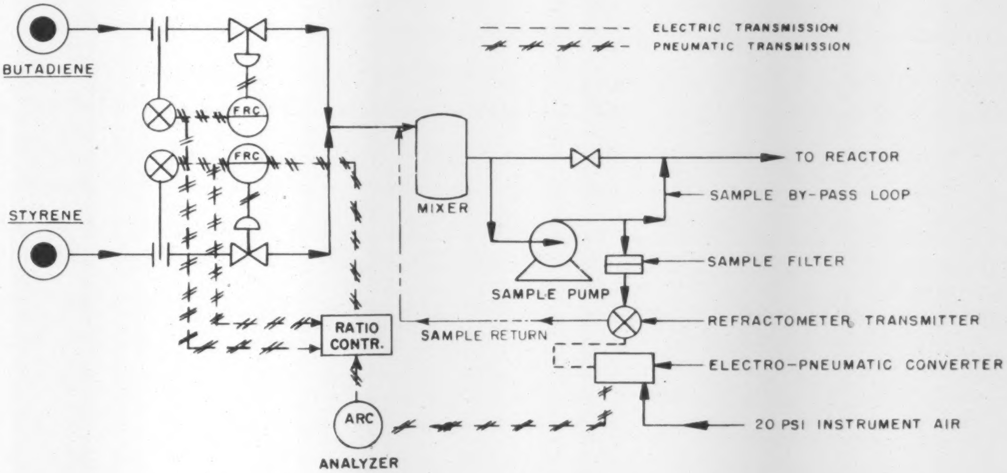
Both feed-stream flow recorder-controllers have proportional plus reset modes of control.

The refractometer used was CEC Type 38-202. Transbutene-2, the standard reference fluid, was locked into the reference side of the sample cell. The instrument was adjusted and zeroed and then put on stream with the unknown blended-liquid product flowing through the sample side of the cell. Full-scale refractive index units was 0.200.

A pneumatic transducer was included to convert the millivolt refractometer output signal to an equivalent 3-15-psig output air signal, which resets the control point of the flow ratio controller (FrRC), which receives its input from the two flow controllers and butadiene feed streams, respectively. Hence variations in refractive index from the standard are recorded and used to bring the product quality back to specification.

Another accepted practice is to transmit the refractometer's electrical output signal to a remotely located electromechanical recorder-controller receiver and use its 3-15 psig output signal either to reset another controller's set point or else to directly actuate the control valve.

Source: Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Calif.


ELECTRIC TRANSMISSION
PNEUMATIC TRANSMISSION
BUTADIENE
FRC
FRC
STYRENE
MIXER
TO REACTOR
SAMPLE BY-PASS LOOP
SAMPLE FILTER
SAMPLE PUMP
REFRACTOMETER TRANSMITTER
RATIO CONTR.
SAMPLE RETURN
ELECTRO-PNEUMATIC CONVERTER
ARC
20 PSI INSTRUMENT AIR
ANALYZER

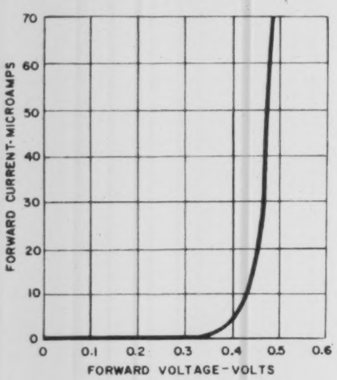
ELECTRONIC

The circuit is the heart of all electronics. Here are 5 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

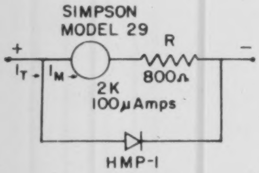
SILICON DIODE PROTECTS SENSITIVE (0 - 100 ua) METER

Sensitive d-c and a-c meters and relays can be damaged when subjected to sustained overloads of more than four times their full-scale value. The nonlinear current-voltage characteristic of silicon diodes in both the forward operating region (this circuit) and the zener operating region can be used to protect a meter or relay.

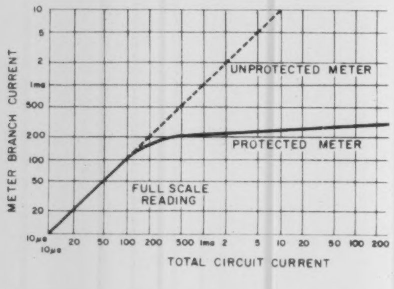
The volt-ampere characteristic (illustration) for a forward-biased HMP-1 silicon diode shows that below 0.3 volt the diode's current is only tenths of a microamp, and its resistance is very high (megoms). Below 0.3-v drop, then, a diode shunted across a meter having a full-scale deflection of 100 microamps causes insignificant error (0.1 ua is only 0.1% of 100 ua).



In the circuit shown the 0-100-ua meter (Simpson Model 29) has a resistance of 2000 ohms. Resistance R is chosen so that total drop across meter and R is 0.28 volt at 100 ua. Hence R is 800 ohms. (If meter has 2800-ohm resistance, resistor R can be omitted.) Below 100 ua all the current flows through the meter and only an insignificant amount through the diode. Above 100 ua, however, the drop across diode exceeds 0.28 volt, and most of the current passes through the diode, with only a portion of current flowing through the meter.



Protection of meter is shown in second graph. For total current of 500 ma (max rating of diode), which is 5000 times the meter rating, only 300 ua flows through the meter.



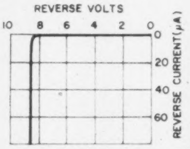
Resistor R was chosen to shunt meter only above full scale. If slight nonlinearity near full scale can be tolerated, a larger value of R will give increased protection.

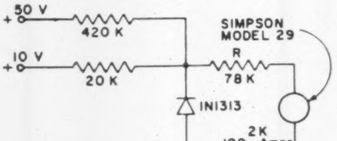
Same technique can be used to protect a sensitive relay.

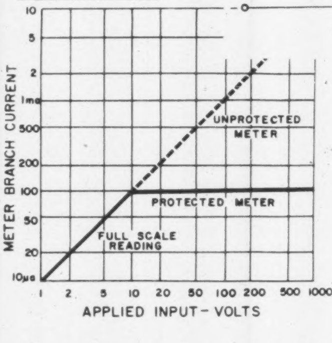
Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitman Ave., Evanston, Ill.

USE OF SILICON-DIODE ZENER CHARACTERISTIC TO PROTECT D-C VOLTMETER

The zener characteristic of a reverse-biased Type 1N1313 silicon diode is shown. Owing to its sharp knee, this characteristic can provide better protection for a meter than can the forward characteristic described previously.







However, note that 8 volts are required to start conduction. This requires a large resistor in series with the 0-100-ua meter (Simpson Model 29), which has 2000-ohm resistance. As 80,000 ohms resistance is needed to develop 8-volt drop at 100 ua, a 78K resistance is added in series with the meter. This gives very good meter protection, but will operate only on 10-volt and higher scales. Another disadvantage (compared to the use of the forward characteristic described previously) is the cost of the zener diode, which is comparable to the cost of the meter.

Protection: When 400 volts is applied to 10-volt input (40 times overload), only 110 ua goes through meter, or 10% overload.

Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitman Ave., Evanston, Ill.

CIRCUITRY

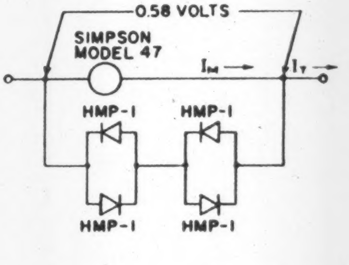
CHARLES F. KEZER

and

MILTON H. ARONSON

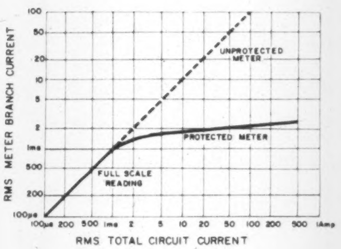
PROTECTING A-C MILLIAMMETER FROM OVERLOAD WITH BACK-TO-BACK SILICON DIODES

In the preceding circuit, one silicon diode was used to protect a d-c meter from overload. Two diodes back-to-back can be used in similar manner to protect an a-c meter from overload.


0.58 VOLTS
SIMPSON MODEL 47
I_M
I_T
HMP-I
HMP-I
HMP-I
HMP-I

Four diodes were required with the meter shown (Simpson Model 47) because of the low resistance of the meter (0-1 ma full scale, 580 ohms resistance, 0.58-v drop across the meter at full scale).

As only 0.3 volt drop across the diode starts the diode to conduct (see curve in previous circuit), two diodes in series will have 0.29-v drop across each when shunted across the meter at full-scale current flow. One set of diodes protects the meter for positive half cycles, the other for negative half cycles of the a-c cycle.

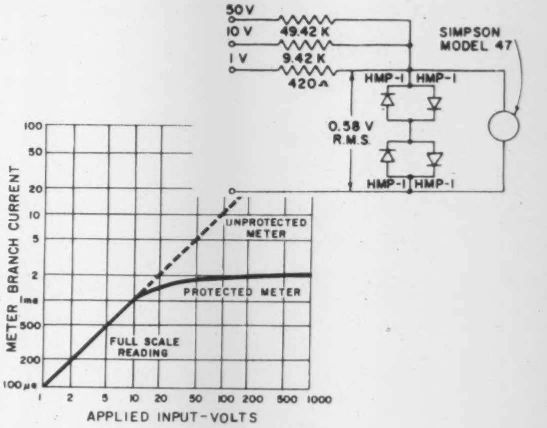


Protection: Curve shows that for 500 ma (500-time overload), only 2.5 ma flows through meter.

Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitman Ave., Evanston, Ill.

PROTECTING A-C VOLTMETER FROM OVERLOAD WITH BACK-TO-BACK SILICON DIODES

Same meter as in preceding circuit is converted into a voltmeter with the external multiplier resistors shown. Sensitivity is 1000 ohms per volt a-c.


50 V
10 V
1 V
49.42 K
9.42 K
420Ω
SIMPSON MODEL 47
HMP-I
HMP-I
0.58 V R.M.S.
HMP-I
HMP-I
METER BRANCH CURRENT
100
50
20
10
5
2
1ma
500
200
100μa
1 2 5 10 20 50 100 200 500 1000
APPLIED INPUT-VOLTS
UNPROTECTED METER
PROTECTED METER
FULL SCALE READING

Same technique as in preceding circuit protects meter from overload.

Protection: When 400 v is applied to the 10-v input, meter current is only twice full scale.

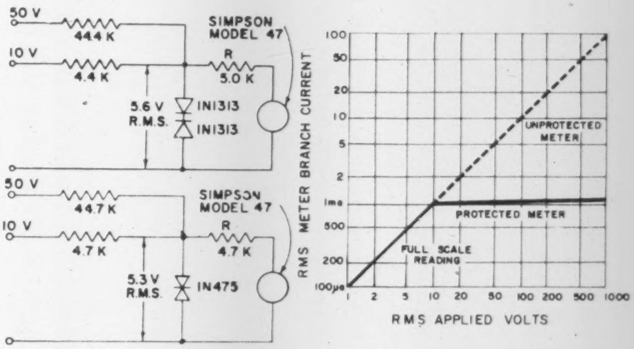
Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitman Ave., Evanston, Ill.

USE OF SILICON-DIODE ZENER CHARACTERISTIC TO PROTECT A-C VOLTMETER

The schematic diagram illustrates the use of two 1N1313 (ZA8) silicon diodes to protect an a-c voltmeter by utilizing their zener characteristics. The curve shows the rms meter branch current as a function of the rms applied voltage (applied at the 10-volt input). For an input voltage of 50 times maximum, the meter is subjected to only 5% more than its full-scale current.

Instead of using a pair of single-anode zener diodes, double-anode silicon junction diodes can perform the same meter protection function since one double-anode diode is electrically equivalent to two single-anode diodes connected cathode to cathode in series.

The second diagram shows the Hoffman type 1N475 double-anode silicon junction diode as the zener protector of an a-c voltmeter. For 40 times the rated input voltage, the meter is subjected to only 10% more than its full-scale value.


50 V
44.4 K
10 V
4.4 K
SIMPSON MODEL 47
R
5.0 K
5.6 V R.M.S.
IN1313
IN1313
50 V
44.7 K
10 V
4.7 K
SIMPSON MODEL 47
R
4.7 K
5.3 V R.M.S.
IN475
RMS METER BRANCH CURRENT
100
50
20
10
5
2
1ma
500
200
100μa
1 2 5 10 20 50 100 200 500 1000
RMS APPLIED VOLTS
UNPROTECTED METER
PROTECTED METER
FULL SCALE READING

Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitman Ave., Evanston, Ill.

Control via Capacitance

Capacitance effects can be used to measure moisture content, liquid or granular level, chemical composition and dimensional changes. Small-changes in capacitance can be used for control of many process variables by this servo-type, null-balance bridge system that combines the sensitivity of an r-f bridge with the simplicity of a 60-cps null-balance servo system.

CAPACITIVE METHODS of measuring process variables have several advantages. When used for measuring liquid level they have the advantage over float or displacement-type methods of having no moving parts, no packed glands, and superior corrosion resistance of the sensing elements. In addition, capacitive methods can measure granular level for which the float or displacement-type method is useless. For dimensional gaging, capacitive methods have the advantage over differential-transformer-type instruments of being non-contacting, and are more simple and stable than radiation-type measuring methods.

The capacitance changes in these measurements vary over wide ranges—from fractions of a uuf in dimensional gaging or composition measurements to several thousand uuf in some level applications. The instrument described is for general-purpose work over this full range of capacitance change.

Principle of Operation

The instrument provides an output proportional to a capacitance change at its input. The output is a shaft rotation which can drive an indicating pointer and also actuate electric or pneumatic controls. The heart of the system (Fig. 2) is an r-f-excited capacitance bridge. The salient feature is that the measurement is made at radio frequency, yet the output driving the servo motor is line frequency, thus combining the sensitivity of r-f measurement with the simplicity of a 60-cps servo system.

The r-f signal is generated by the oscillator, modulated by a 60-cps wave, and supplied to the bridge (Fig. 2, left). If the bridge is unbalanced due to a change in capacitance, a modulated r-f signal appears across its output terminals and is superimposed on the unmodulated r-f reference signal. This composite signal is then demodulated, yielding a 60-cycle wave which, in magnitude and phase, depends on the bridge unbalance. After amplification, this signal is applied to a motor, causing it to run either clockwise or counterclockwise, depending on the phase of unbalance. A variable capacitor linked to the motor will be turned in the direction necessary to bring the bridge back to balance; the measure of the original unbalance is the amount of motor shaft rotation necessary to return the bridge to balance.

The basic bridge shown in Fig. 2 has been modified to that shown in Fig. 3 to provide adjustability over a wide range; the four capacitors, C_r, C_s, C_x, and C_z form the bridge. C_x is the capacitance to be measured; C_z is a variable capacitor (set equal to C_x when C_x is at its minimum value). C_r is the variable rebalance capacitor, and C_s is a preset capacitor (equalling C_r when C_r is at its minimum value).

To put the system into operation, C_z is adjusted so that the instrument indicates zero when a zero indication is required by the measured variable. Then the span control (C_v) is set for full-scale deflection under conditions requiring a full-scale indication. The system is now ready for operation.

Measurement

GEORGE REVESZ

Robertshaw-Fulton Controls Company

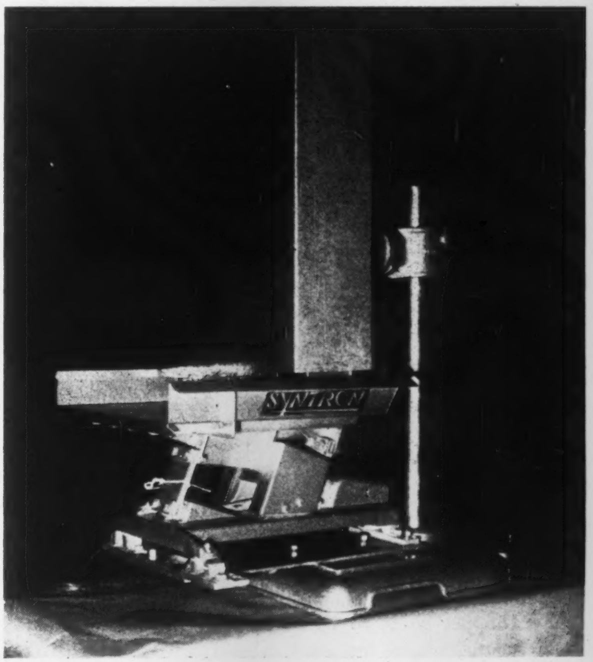


FIG. 1. **MEASURING CELL** for moisture measurements. Vertical element contains the electrodes. Vibratory feed-belt with driving motor is at bottom. Material falls through vertical chute, and is moved by vibrator.

It can be shown by network theory that the capacitors added at the left of the bridge in Fig. 3 form a Y network permitting changing the span of the instrument indication by C_v with no effect on the instrument at its zero condition. In other words, zero and span can be adjusted independently.

Range Factors

The minimum span (the minimum capacitance change to give full-scale reading) depends on the length of cable connecting the measuring element with the instrument. With 5′ of cable the minimum span is 0.5 uuf, increasing to 15 uuf with 125′ of cable. The span can be increased to above 10,000 uuf. The span adjustment has five step ranges with a continuous adjustment within each range to allow a 10-to-1 change in span setting; this change in span has no effect on the zero setting.

The sensitivity of the instrument (the minimum change necessary to give a noticeable change in reading) is better than 0.25% of the span. No noticeable change in reading results from a ±15% change in line voltage; an ambient temperature change of 1°F will give rise to an apparent capacitance change of 0.003 uuf. The response time is 3.5 seconds for a full-scale change.

The probe arrangement should give the maximum possible change in capacitance per unit change in the variable being measured, while minimizing secondary effects that may produce errors in the readings. Several applications will illustrate some ways by which these secondary effects can be removed.

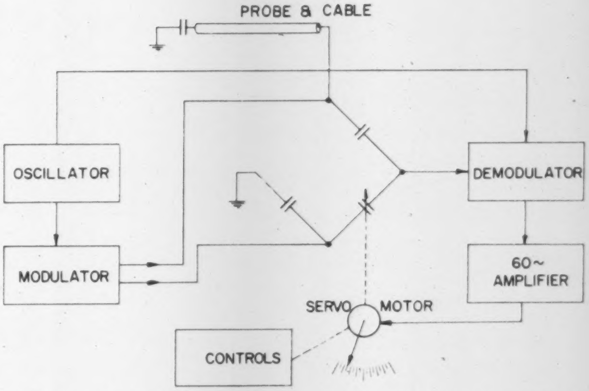


FIG. 2. **BLOCK DIAGRAM** of the basic instrument.

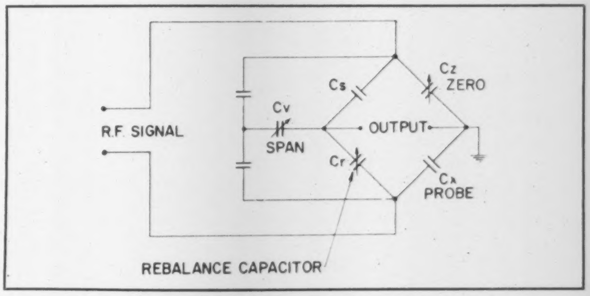


FIG. 3. **DETAILS** of bridge circuit.

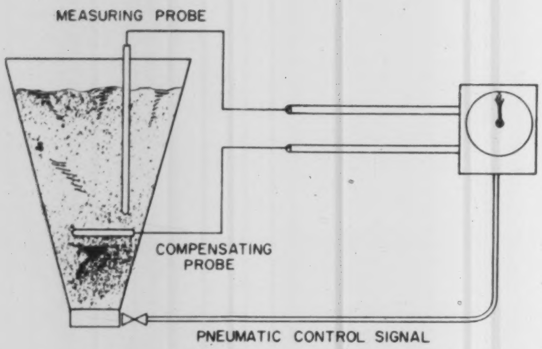

MEASURING PROBE
COMPENSATING PROBE
PNEUMATIC CONTROL SIGNAL

FIG. 4. CONTROL of hopper level.

Level Measurement

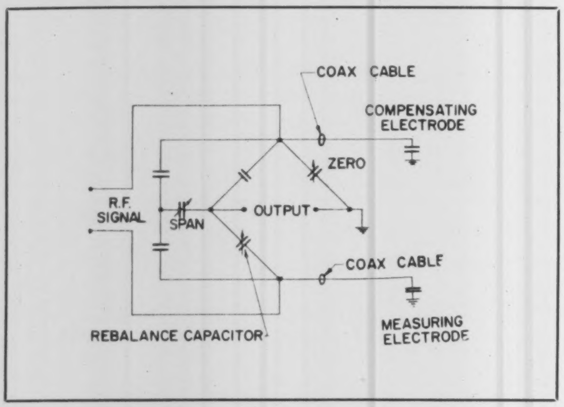
In Fig. 4 the problem is to control level of granular material in a hopper. Temperature effects can be eliminated by a compensating probe. This is mounted in a hopper so as to be covered by the material at all times, and has the same capacitance as the measuring probe when the material is at the desired control level.

This is shown electrically in Fig. 5. At the control point the two capacitances are equal so any over-all change in dielectric constant will have no effect on the bridge balance.

Composition Measurements

Fig. 6 shows moisture measurement of granular materials. The material passes continuously through the measuring cell, which senses the moisture variation by a change in capacitance. The temperature compensator is located near the measuring probe so that the material passes *around* the compensating probe (which corrects for variations in dielectric constant due to temperature changes of the material). A controller can adjust the drying process according to variations of moisture content of the material. The system can indicate changes in moisture down to fractions of a percent.

FIG. 5. ELECTRICAL connections for a compensating electrode.


COAX CABLE
COMPENSATING ELECTRODE
ZERO
R.F. SIGNAL
SPAN
OUTPUT
COAX CABLE
REBALANCE CAPACITOR
MEASURING ELECTRODE

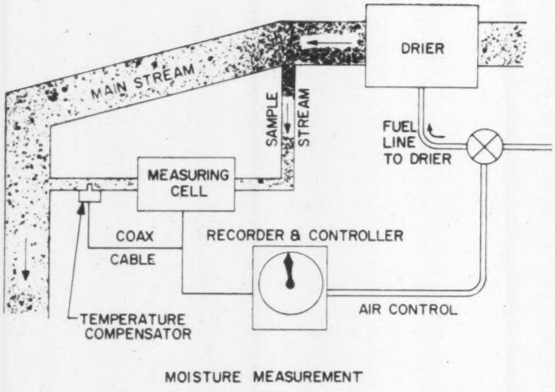

DRIER
MAIN STREAM
SAMPLE STREAM
FUEL LINE TO DRIER
MEASURING CELL
COAX CABLE
RECORDER & CONTROLLER
TEMPERATURE COMPENSATOR
AIR CONTROL
MOISTURE MEASUREMENT

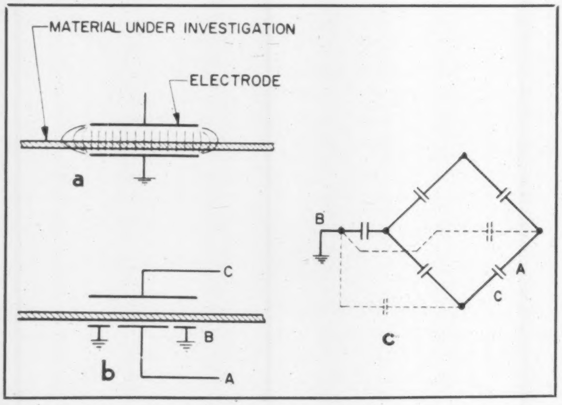
FIG. 6. CONTROL of a drying process by continuous moisture measurements.

Gaging of Sheet Material

An advantage of capacitive measuring of thickness is that no contact need be made with the measured material. A typical example is gaging wet fibreboard sheets. Being wet and conductive, the top surface of the sheet acts as the grounded plate of the probe. The sheet, moving past the single electrode plate on a conveyor, can be gaged to an accuracy of ±1/64″ around nominal thickness ranging from ¼″ to 1″.

Dry and non-conducting materials like glass sheets often show errors introduced by bouncing or tilting. Parallel-plate electrodes give readings independent of the sample's position only if these electrodes are infinite; finite electrodes introduce errors due to changes in stray capacitance (Fig. 7a). This can be corrected by adding a guard ring as shown in Fig. 7b, connected electrically as shown in Fig. 7c. At balance, points A and B are equipotential and, hence, voltages between A-C and B-C are identical; thus the field between C and A (the measured capacitance) is parallel. The strays affect only capacitance B-C and do not influence the readings because they are outside of the bridge.

FIG. 7. GUARD-RING method of compensation in thickness gaging.


MATERIAL UNDER INVESTIGATION
ELECTRODE
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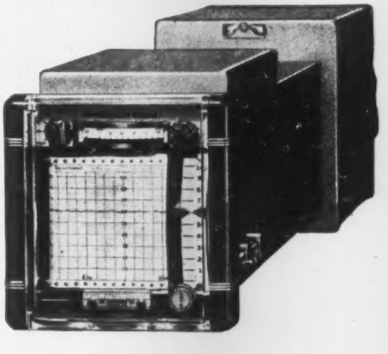

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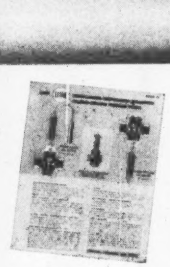

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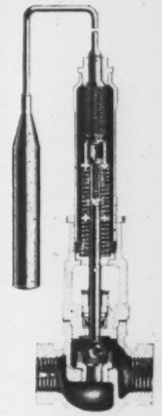

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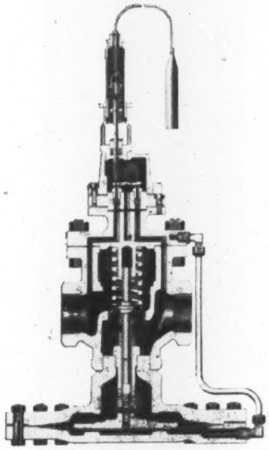

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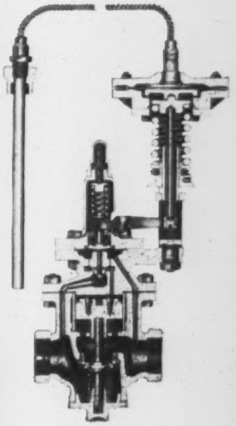

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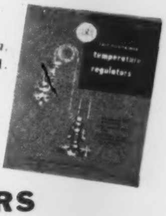

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A DIRECT-READING VISCOMETER

Prototype instruments for determining directly the kinematic viscosity of liquids have been developed using the restrictions-in-series principle. Although not an absolute method, a simple calibration with liquids of known viscosities permits the subsequent measurement of the viscosities of other liquids by reading a single manometric column; no corrections or calculations are required. Theory, construction and operation of instruments having the range 0.5 to 5.0 centistokes are discussed.

MONTGOMERY R. SHAFER
National Bureau of Standards

A DIRECT-READING VISCOMETER has been developed at the National Bureau of Standards under a program sponsored by the Navy Bureau of Aeronautics[1]. Designed specifically to measure the kinematic viscosity of liquid hydrocarbon fuels, the instrument has been used to determine the viscosity of liquids used in the adjustment and calibration of fuel-metering accessories for aircraft engines.

This instrument provides a convenient, rapid measurement of viscosity within an accuracy of 2%. It is simple to operate, direct-reading, involves no electronic components, and requires no power connections.

The prototypes developed at the Bureau have a range of about 0.5 to 5.0 centistokes. This encompasses the viscosity of fuels commonly used by the aviation industry. However, the instrument range may be varied by altering the type and size of the two fixed restrictions.

Theory

The general theory of the viscometer as developed by dimensional analysis shows that viscosity is a function of the losses in head or pressure across fixed flow restrictions.

The flow system shown in Fig. 1 consists of an entrance chamber (3), a fixed flow restriction (1), an intermediate flow chamber (4), a second fixed flow restriction (2), and an exit chamber (5), all connected in series. Assume this system to be filled completely with a liquid of density ρ, and absolute viscosity, η, flowing at an unknown rate.

If the difference in pressure between chambers (3) and (5) is designated as Δp_t and the pressure drop across restriction (2) as Δp_2, then the relation:

$$\eta = D\sqrt{\rho\,\Delta p_t}\; f\,(\Delta p_t/\Delta p_2) \qquad (1)$$

can be obtained by dimensional analysis where D represents the configuration of the flow system and f means "function of."

If a flow control valve (9) maintains the loss in pressure Δp_t at some selected constant value ΔP_t when liquids of different densities and viscosities are flowing, then equation 1 becomes:

$$\eta/\sqrt{\rho} = D\sqrt{\Delta P_t}\; f\,(\Delta P_t/\Delta p_2) = Af'\,(\Delta p_2) \qquad (2)$$

where A has a constant value for any given flow system and selected constant total loss in pressure, ΔP_t.

When manometers are used and contain the same liquid as that flowing through the system equations

---

[1] United States Patent No. 2,700,891, A Direct-Reading Viscometer.

Presented at SCMA-LAHJC, Short Course, March 26-27, 1959, Wilmington, Calif.

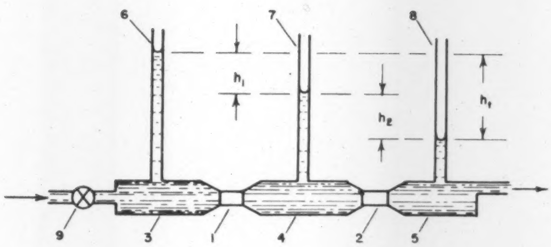

FIG. 1. SCHEMATIC of flow system.

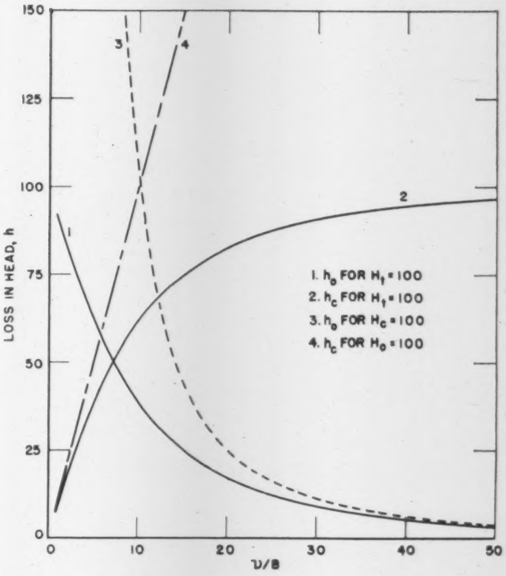

FIG. 2. LOSS IN HEAD versus viscosity for an orifice and capillary in series.

(1) and (2) become:

$$v = \eta/\rho = D\sqrt{gh_t}\ f\ (h_t/h_2) \qquad (3)$$

and

$$v = \eta/\rho = D\sqrt{gH_t}\ f\ (H_t/h_2) = Bf'\ (h_2) \qquad (4)$$

respectively through use of the familiar relation $\Delta p = \rho gh$, and v represents kinematic viscosity.

Equation (4) means that if the total loss in head h_t is always maintained at the constant value H_t when different liquids are flowing in a system of fixed configuration, the loss in head h_2 will be a function of kinematic viscosity alone.

The development of a practical meter based on equation (4) requires (1) indicating h_2 and H_t, (2) controlling H_t, and (3) selecting the flow characteristics of restrictions (1) and (2) to give the function f′ a usable form. After final construction of the instrument, calibration tests with liquids of known viscosities must be performed to determine the exact form of the function f′.

It can be shown that when any one of the three quantities h_t, h_1, or h_2 is held constant, the kinematic visocity is a function of either of the other two. The form of the function is different for each possible combination, and the characteristics of the final instrument can be varied to suit specific needs as to method of operation, range, and sensitivity.

Developing Function f

Relations will now be developed showing the approximate forms of the function f which apply for the particular case of a capillary tube (loss in head = h_c), in series with a thin-plate orifice (loss in head = h_o). The relations to be developed will be approximate because it is assumed the capillary end effects are insignificant, and that the coefficient of discharge of the orifice is constant throughout the operating range. Once an actual instrument is constructed, calibration with a few liquids of known viscosity automatically includes the exact effect of these factors approximated in the theory.

The Hagen-Poiseuille law gives the pressure drop for laminar flow at a volume rate Q through a tube of length L and radius r as:

$$\Delta p_c = 8\eta QL/\pi r^4 \qquad (5)$$

Flow (Q) is the same through both restrictions. From the well known orifice flow equation:

$$Q = (\pi/4)\ Cd^2\sqrt{2gh_o} \qquad (6)$$

where C is the coefficient of discharge and d the throat diameter.

Using the relation $\Delta p_c = \rho gh_c$, and combining equations (5) and (6) gives:

$$v = \eta/\rho = \left(\frac{r^4\sqrt{g/2}}{2LCd^2}\right)\left(\frac{h_c}{\sqrt{h_o}}\right) = Bh_c/\sqrt{h_o}$$

$$= Bh_c/\sqrt{h_t - h_c} = B(h_t - h_o)/\sqrt{h_o} \qquad (7)$$

It is seen from equation (7) that if either h_t, h_c, or h_o is held constant at all times during the use of a given instrument, then each of the other two losses in head is a function only of the kinematic viscosity of the flowing liquid. Equation (7) gives the approximate form of the function f′ of equation (3) and (4) and is useful in preliminary predictions of performance.

Fig. 2 is a plot of equation (7), showing how the individual losses in head across the orifice and across the capillary tube vary with v/B, as H_o, H_c, and H_t

are separately kept constant at an arbitrary value of 100 units of scale length. It is seen that holding the loss in head across the orifice constant (curve 4) and measuring the loss across the capillary will give constant sensitivity from a low viscosity to a maximum which depends upon the value of B and the length of the scale.

Holding the loss in head across the capillary constant (curve 3) and measuring the loss across the orifice will cover the range from infinity to a minimum which also depends on the value of B and the length of the scale. This method gives excellent sensitivity at the higher values of h_o. Holding the total loss in head constant (curves 1 and 2) and measuring the loss across either restriction gives a logarithmic-type calibration. This is useful as viscosities will be indicated to a nearly constant-percentage accuracy for values of h_c or h_o in the range 0.2 H_t to 0.7 H_t.

The curves are applicable only for the condition of laminar flow in the capillary. Turbulent flow will give different but useful results. Also, a calibration curve with an inflection point is obtained in the transition region. This region should be avoided and operation planned either at Reynold's Numbers below 100 or greater than 3500.

Prototypes

The first prototype instrument constructed is shown in Fig. 3. This viscometer has a range of 0.4 to 5.0 centistokes and was designed to measure the viscosity of hydrocarbon liquid fuels used in the aircraft industry. It has an accuracy of about 2% and can be used with collected samples introduced through a leveling bulb, or for continuous indication.

The instrument has a capillary (0.025-cm radius and 6-cm long) in series with a thin-plate orifice of 0.03-cm diameter. The total loss in head across both restrictions is maintained constant during operation and the loss in head across the orifice is used as an indication of viscosity. A micronic filter is included to eliminate dirt and a control valve provides manual adjustment of total head for continuous indication. The built-in by-pass provides for eliminating gas and vapor and causes a reasonably rapid introduction of new liquid into the instrument during continuous operation.

This prototype has been in operation in our laboratory over six years, has excellent stability of calibration and has proved adequate for collected sample applications. Its primary disadvantages are (1) slow response of the indicating manometer because of the small flow restrictions, and (2) difficulty in controlling accurately the total loss in head during continuous flow applications.

A second prototype which overcomes these disadvantages to a considerable extent is shown in Fig. 4. A faster response is obtained by using an orifice of 0.06-cm diameter in series with a capillary restriction consisting of four 0.025-cm radius tubes in parallel. Also, an overflow weir is provided in the inlet line, making adjustment of the total head manometer easy and rendering this level insensitive to moderate variations in the supply pressure.

One difficulty encountered is the formation of vapor during throttling from supply pressure to atmosphere when working with a high-vapor-pressure liquid such as gasoline. This vapor within the viscometer and its manometer will cause errors in the viscosity indication.

The viscometers described indicate only at the temperature existing within the instrument. Where temperature varies it may be desirable to know the viscosity of the liquid at some reference temperature. One solution is automatic temperature control.

If the viscosity-temperature relationship of the process liquids are known, perhaps the instrument shown in Fig. 4 could be supplied with a scale mounted on a rotating drum. The scale could be a graph similar in configuration to the ASTM Standard Viscosity-Temperature Charts for Liquid Petroleum Products, drawn to conform to the actual calibration characteristics of the particular instrument. In operation, the angular position of the drum would be adjusted manually to correspond to the temperature existing within the viscometer. The reading indicated would be viscosity of the liquid at the reference temperature. This mode of operation has not been tried, but it seems feasible for applications requiring only moderate accuracy.

Low-Accuracy Design

Fig. 5 shows a suggested design of a viscometer for use with collected samples of about 5 to 10 cc in volume. An approximate range of 1 to 10 centistokes can be obtained with a capillary 1.5 mm in diameter and 15-cm long and an orifice diameter of about 0.75 mm. The approximate accuracy should be about 10% of indicated.

In operation, the instrument is placed in a vertical position and the liquid sample introduced into the reservoir at the top. The liquid level in the reservoir will eventually reach the reference mark as gravity causes the liquid to flow out through the orifice in the bottom. At this instant the height of the liquid in the manometer is a kinematic viscosity indication. This may be suitable for applications in which a quick indication of approximate viscosity is desired. Its advantages are the simplicity of construction and operation, convenience of cleaning, construction of glass if desired, and the feature of direct indication of viscosity.

Use of Pressure Gages

The pressure-type viscosmeter could use differential-pressure gages or transducers instead of manometer columns to measure the loss in pressure across the flow restrictions Equation (2) shows that such an instrument will *not* indicate kinematic viscosity directly, but rather the quantity $n/\sqrt{\rho}$ or $\nu\sqrt{\rho}$. The instrument will be direct reading if the density of the liquid remains essentially constant with variations in viscosity. However, where the variations in density are significant, corrections based on the square root of density must be applied.

The pressure-type instrument will measure the drop in pressure across each of the restrictions or both of them in series, depending on the mode of operation selected. As only differential pressures are involved,

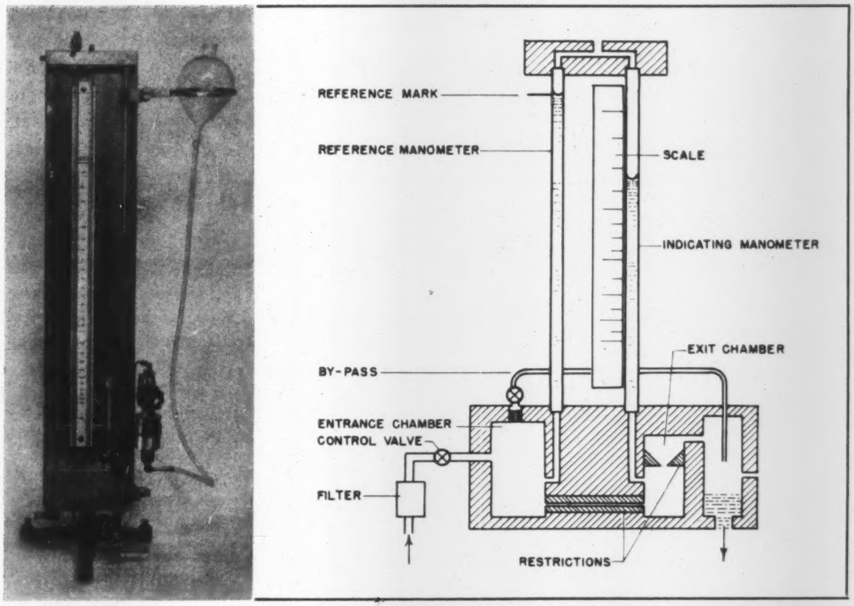

FIG. 3. FIRST direct-reading viscometer prototype, and schematic cross section.

operation of the instrument at any desired pressure level would be possible. Also, it is believed that suitable pressure-regulating devices are available for the automatic control of that pressure drop which must remain constant, thus eliminating manual operation of the throttling valve.

Conclusions

Although the combination of an orifice and a capillary for the determination of viscosity is not original, the relations shown in equations (2) and (4) demonstrate that these have much wider application than is appreciated. For example, it is not necessary that the orifice be operated only under conditions which cause the discharge coefficient to remain constant. Also, it is not necessary to eliminate end-effects from the capillary tubing through the use of special pressure taps or restricted operation at extremely low velocities. In fact, correct operation is not confined to an orifice and capillary, but *other combinations of restrictions are suitable provided one of these is more sensitive to the influence of viscosity than the other.*

The instrument does not use an absolute method. Rather, a calibration of each viscometer with liquids of known viscosities is necessary to determine the exact calibration characteristics. However, experience has demonstrated the calibration will be retained over a period of years provided the configuration of the flow restrictions is not changed. Such changes can occur through dirt and gum deposits, chemical action, or mechanical injury. Thus, adequate filtration and reasonable care in the selection of materials for the restrictions and their handling are necessary.

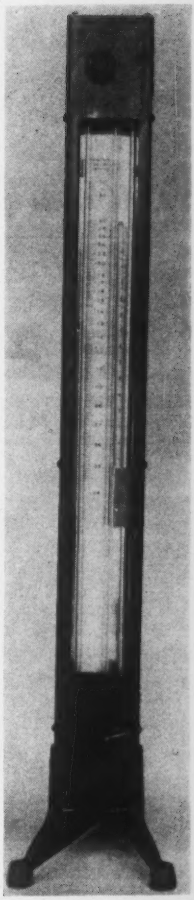

FIG. 4. SECOND prototype direct-reading viscometer.

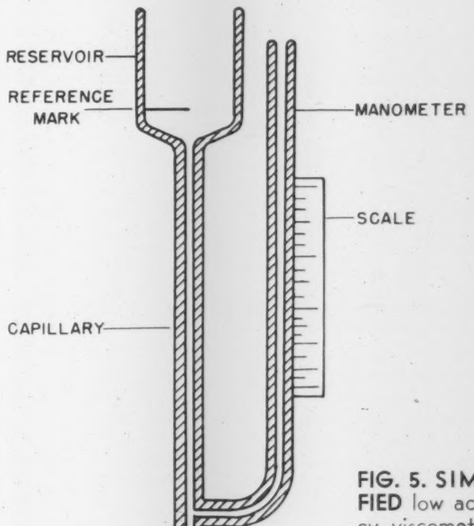

FIG. 5. SIMPLIFIED low accuracy viscometer.

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- Solid aluminum pre-patch panel is light and easy to handle. Its 3450 holes are precision drilled to .001 of an inch. It will not warp, bend or crack.
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- 3450 contacts in the patch bay are plated with 24 carat gold. This provides unusually good electrical contact... important for accuracy at low voltages and currents.
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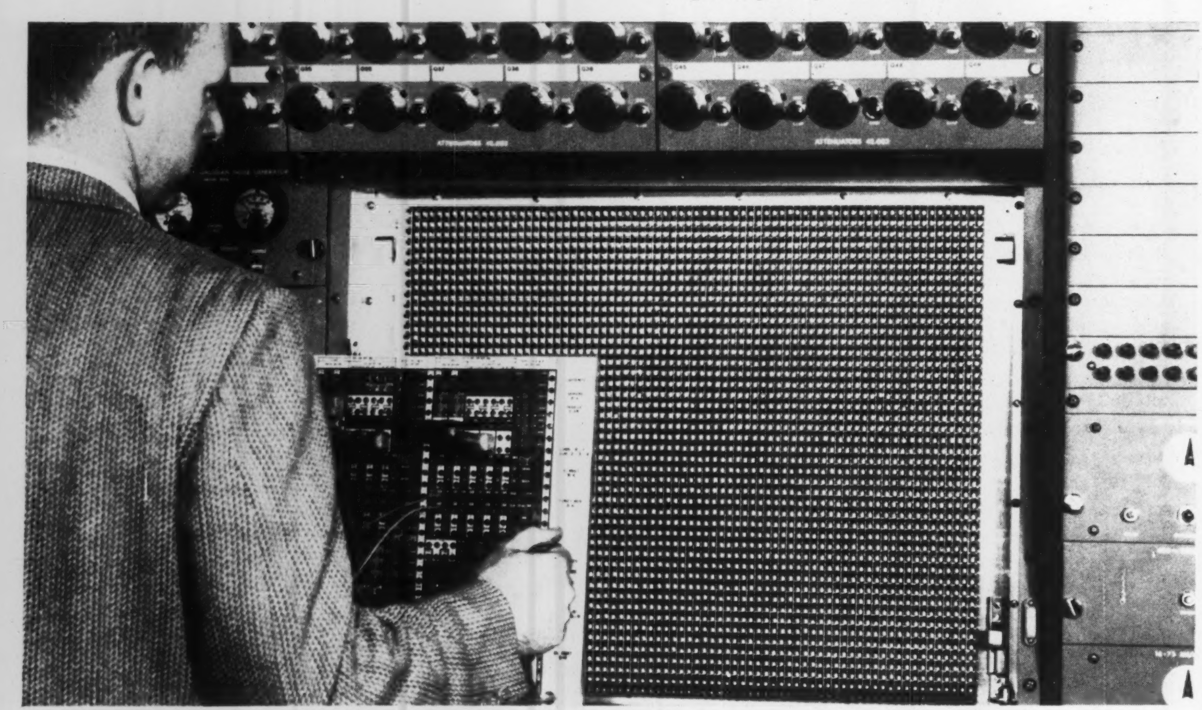

Contacts in patch bay are plated with 24 carat gold for maximum accuracy at low voltages and currents.

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The SIMULATION COUNCIL Newsletter

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Bits

This month a report on the Southeastern Simulation Council meeting of 23 January 1959 at ARO, and one paper from the Eastern Simulation Council meeting of 16 February 1959 at Grumman.

The first consists of the abstract of a paper, "Determination of Forcing Functions from the Response of a Known Physical System" by *W. K. McGregor*, and a guess by ye Ed as to what Mac really explained in the talk, plus a description of the subject matter of a paper "Solution of Simultaneous Partial Differential Equations" by *S. P. Ragsdale*, and an abstract of a thesis by *Homer Powell* on "Solution of Differential Equations through the Use of Number Series."

The paper from the Eastern Council, entitled "Development of a Multipurpose Research Simulator" by *E. J. Kennelly* describes what we usually refer to as Flight Trainers.

There is little Info and no Thot in the rest of the *Newsletter*.

We will try to do better next month, but at the moment many of our Thots are not printable, and some are not concerned with Simulation!

Pieces

SOUTHWESTERN S C MEETING OF 23 JAN ON FORCING FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS

Twenty-six representatives of about a dozen different organizations signed the register for the January 23rd meeting of the Southeastern Simulation Council at the Arnold Engineering Development Center in Tullahoma, Tennessee.

McGregor on Determination of Forcing Functions

Dallas Russell (ARO, Inc., Tullahoma) welcomed the group and introduced *W. K. McGregor*, who spoke on "Determination of Forcing Functions from the Response of a Known Physical System."

Here is Mac's own abstract of his talk, verbatim:

The age-old instrumentation problem, known generally as the "Converse Problem," is attacked in a new light by use of simulation and feedback techniques. The problem is described as "given the response and law of a known physical system, what is the forcing* function?"

Previous methods of solving this problem were to attempt to correct transient data taken on high-speed recording oscillographs. Methods used depended on knowledge of the differential equation and on the ability to obtain slope measurements or Fourier series from the records. The results were time-consuming and usually inadequate.

The simulation method introduced in this paper is based on accurate simulation of the measurement system dynamics on an electronic analog computer. From an oscillogram of the measurement system response to a known forcing function, the differential equation of the measurement system is obtained. The equation is simulated on an analog computer, and by use of feedback around the simulated system, a compensated system with much faster and more stable response is produced. The input to this new system is the measurement system output. The error signal of the new system is then a faithful reproduction of what must have been the input to the measurement system.*

(Editor's Note:)

*Get it? (I don't). Mac's a smart boy, but this time his abstract was too abstract. What this dense one *guesses* he means is: Given an imperfect measuring system (Fig. 1) with input e_{im} the output e_{om} will be $e_{im} + \epsilon_m$, where ϵ_m is the error introduced by the measuring system. If this measuring system is then simulated, the simulated system will have an output $e_{os} = e_{is} + \epsilon_s$ for an input e_{is}; and if the simulation is accurate, ϵ_s will equal ϵ_m. If a feedback loop around the simulated system can now be developed which will make $e_{os} = e_{is}$, the output of this feedback system must be $-\epsilon_s$.

If then the output of the measuring system e_{om} is the input to the simulated system e_{is} we have:

$$e_{is} = e_{om} = e_{im} + \epsilon_m$$

At the summing junction the feedback signal $-\epsilon_s$ is added, so the signal actually driving the original simulated system (which we will call e_d to prevent confusion

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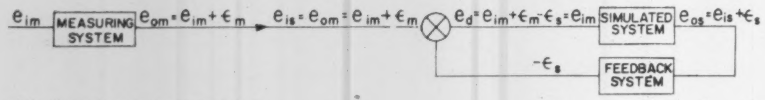
*Forcing function—the outside source of energy that acts on a system, forcing it into its response.—ED.


e_{im}
MEASURING SYSTEM
$e_{om} = e_{im} + \epsilon_m$
$e_{is} = e_{om} = e_{im} + \epsilon_m$
$e_d = e_{im} + \epsilon_m - \epsilon_s = e_{im}$
SIMULATED SYSTEM
$e_{os} = e_{is} + \epsilon_s$
$-\epsilon_s$
FEEDBACK SYSTEM

with the other error signals) is:

$$e_d = e_{im} + \epsilon_m - \epsilon_s$$

and as $\epsilon_m = \epsilon_s$, $e_d = e_{im}$.

Which is what Mac said to begin with (I think).—Ed.

Three methods of applying the measurement system output to the simulated system are discussed. They are (1) direct input of the instrument signal to the simulation; (2) replay of magnetic tape-recorded signal into the simulation; and (3) transfer of an oscillograph record to graph paper and subsequent relay into the simulation at extended time scale from an x-y curve follower.

Questions following Mac's talk brought out the facts that:

The frequency of the simulated system is the most critical part;

The acceleration term as well as the velocity term must be cancelled out;

They were dealing with a second-order system, specifically a thrust-stand which was shocked by displacing it with a piano wire, then cutting the wire.

Ragsdale on Simultaneous Partial Differentials

Sam Ragsdale (ARO, Inc.) was the next speaker. However his paper, "Solution of Simultaneous Partial Differential Equations," a copy of which was sent to us by *Ed Holmes*, Secretary of the Southeastern Simulation Council, is too erudite for full treatment in this *Newsletter**.

Suffice it to say that it described a method of using an analog computer (in this case a GEDA) to solve equations of the form

$$\frac{\partial T_f}{\partial x} = H_f(T_s - T_f) - H_p$$

$$\frac{\partial T_s}{\partial t} = H_s(T_f - T_s) + \alpha \frac{\partial^2 T_s}{\partial x^2} + He$$

which arose in connection with the development of a graphite heater for simulating trajectory temperatures at the Gas Dynamics Facility of ARO, Inc.

The values of five of the variables required as functions of time are derived from x-y plotters with curve followers, and are fed into the analog computer, which solves the equation necessary to plot the temperature histories of stations along the graphite bar heater.

Those interested in (and capable of understanding) more about the technique are urged to get in touch with *S. P. Ragsdale*, Technical Service, ARO Inc. AEDC, Tullahoma, Tenn.

Powell on Number Series

The third speaker was *Homer Powell*, also of ARO Inc., who spoke on "The Solution of Differential Equations through the Use of Number Series," which Ed Holmes tells us was part of a Master's thesis. Ed sent us an abstract of this talk, as follows:

The scope of this research study is essentially the development and presentation of a Number-Series method for the numerical solution of many types of differential equations. The method involved is applicable to manual or digital computer solutions.

The approach draws upon the methods and techniques of analog-computer solutions. The components required for an analog solution are simulated on a digital computer by programming the equivalent mathematical function of that component. The justification for the method is provided by Number-Series operations. For example, the development of a formula for use as a simulated integrator is obtained from the Number-Series integrating operation. The simulated components are then interconnected in such a way that during the sequence of computer instructions, the stepping from component to component mathematically represents the differential equation or system under study.

Various degrees of accuracy are available by this method, and a variety of equation types may be solved. The most serious disadvantage when compared to analog computer solutions is the time required to solve the problem.*

* * *

After lunch the group toured the Gas Dynamics Facility, the Propulsion Wind Tunnel, and the Engine Test Facility.

At a dinner meeting *Dr. C. H. Weaver* (University of Tennessee) told about using operational amplifiers in teaching the University's Electrical Engineering Department.

EASTERN S/C MEETING OF 16 FEB ON MULTIPURPOSE RESEARCH SIMULATOR

We will comment further on the 16 February meeting of the Eastern Simulation Council at Grumman Aircraft Engineering Corporation, (Bethpage, Long Island, New York) in a subsequent *Newsletter*, but we want to take the opportunity this month to present separately *E. J. Kennelly's* paper on "Development of a Multi-purpose Research Simulator," which was given at that meeting.

One reason we do this is that we found it unusually interesting and, judging others by ourselves, thought you would. Another is that it is the only complete presentation which we received from that meeting. We give it to you just as the author wrote it, because we can find no room for improvement.

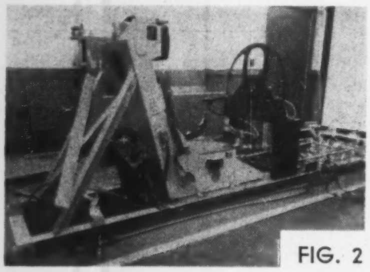


FIG. 2

Kennelly on Development of Simulator

By way of introduction, Mr. Kennelly said that research simulators have been used at Grumman for a number of years. These simulators consisted of an airplane cockpit with typical flight instrumentation, associated hardware that could not be easily analogued, and an optically projected horizon viewed through the wind screen (Fig. 2).

From our past experience we decided to design a multi-purpose research simulator consisting of equipment which could be breadboarded together to meet the requirements of the engineers and scientists doing the various studies, Kennelly continued. This equipment consists of a motion simulator, a large variety of servo equipment for driving various instruments, and a visual display of the "outside world."

The criterion for determining the

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*Another way of saying "over my head."—Ed.

*Good! Now whatsa Numbers Series?—Ed.

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An Electronic Sine-Cosine Former for Fast Resolution

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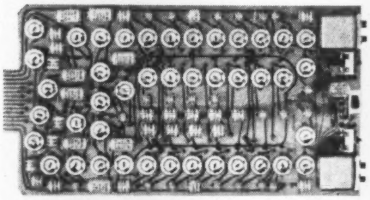
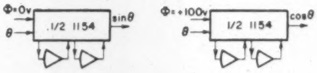


The Model 1154 consists of two identical computing channels, both mounted on the single printed-circuit board shown above. Each channel will generate the sine or cosine of an input voltage when supplemented by two patched-in amplifiers. The circuitry consists of factory-adjusted diode networks. Output curves are formed from 18 line segments.



Diagrams above show how a computing channel in the 1154 may be connected with amplifiers and reference voltage (ø) to generate either sinθ or cosθ. The complete 1154 will thus generate both sine and cosine for use in resolution.

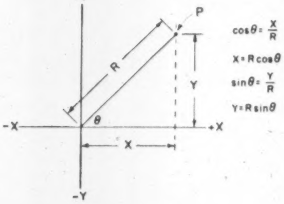
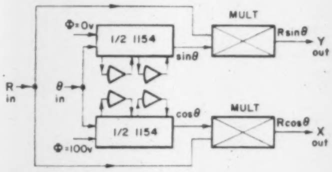
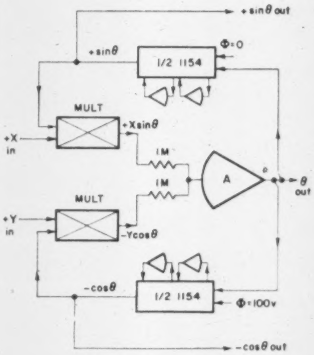


Diagram and formulae above show the elementary relations between polar and rectangular coordinate systems. As you will see following, the Model 1154 permits us to generate X, Y given R, θ and conversely to generate R, θ given X, Y. Coordinates may be generated continuously as point P moves through all four quadrants.



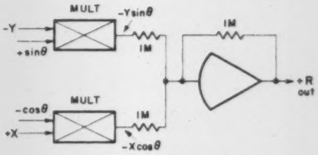
Hookup for forward resolution (i.e. transforming polar to rectangular coordinates) is shown above. An important advantage of electronic resolution is that the multipliers are free to generate non-trigonometric products when not used in a resolving circuit.



To accomplish inverse resolution (transforming rectangular to polar coordinates) we first generate θ using the feedback circuit diagramed above. Operation of this circuit is based on the relationship

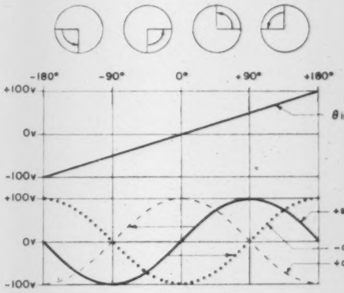
$$X\sin\theta - Y\cos\theta = 0$$

The output of amplifier A must be θ because only at that value will the outputs of the multipliers be equal and opposite in sign, thus producing the necessary net current of zero at the amplifier summing junction. Amplifier A is shunted by a .001μf capacitor to insure stability. Sinθ and cosθ outputs are used to generate R in the following circuit.

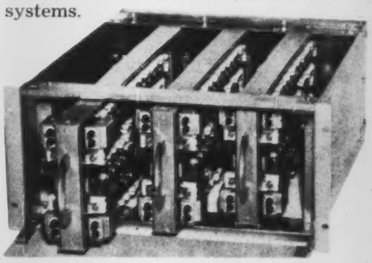


Operation of this circuit is based on the relationship

$$X\cos\theta - Y\sin\theta = R$$



Above is the transfer function of an 1154 channel. With ø input zero, the $+\sin\theta$ curve is produced. This curve may be shifted ±90° by applying a voltage at the ø input. Thus ø = +100v produces $+\cos\theta$; ø = −100v creates $-\cos\theta$. By shifting the curve less than 90°, one can resolve skewed coordinate systems.



Six Model 1154's (a total of 12 computing channels) fit into this 19″ chassis.

Complete specs and prices are available on request.

C11

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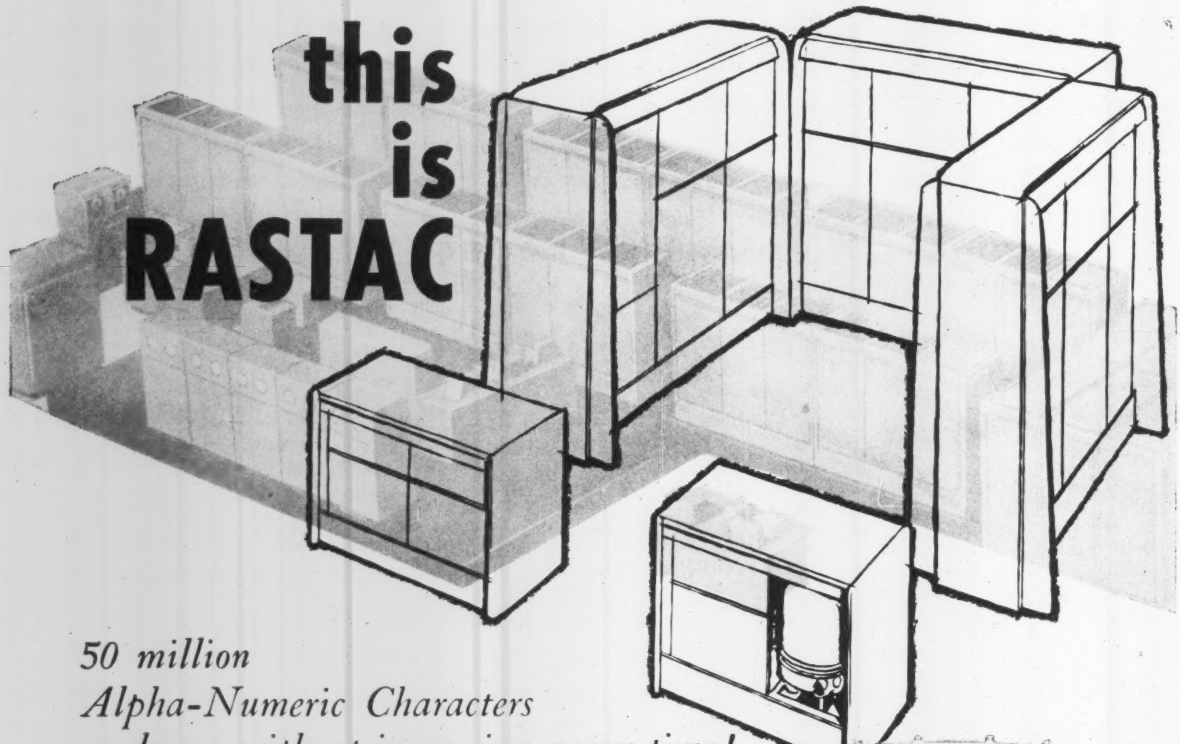

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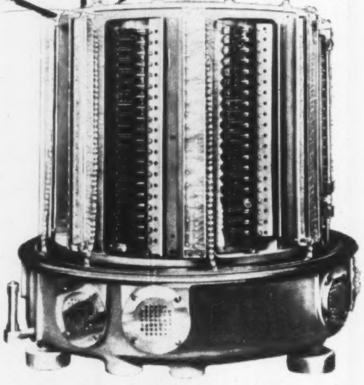

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need for this type of simulator is simply whether or not the human is a critical element in the system, either as a controller or as a decision maker, since the inclusion of a human being defies a paper analysis. As a matter of fact, the degree of simulation required is determined by how critical the performance of the human controller is. Fortunately, in the past, the human performance has not been the limiting factor and therefore the degree of simulation has not been especially critical.

However, there are a number of trends today which are rapidly reducing the margin of pilot error. This is graphically illustrated by the rapid increase in accidents reported by the Armed Services that are attributed to pilot error. Two of the most important trends have been the increase in aircraft speeds and the increase in system complexity which the pilot must control. The first reduces the pilot's decision time, and the second increases the number of decisions required. **Some people believe that present-day systems have reduced the margin for pilot error below any reasonable minimum, and the accident reports support this argument.**

To study these areas our dynamicists and our human factors people set up requirements for new simulation equipment. This equipment can be broken down* into several broad fields.

In the VTOL and STOL areas, there are problems of control which are not only unusual in our experience, but also particularly unusual because near-the-ground flight poses critical control problems which require special simulation of ground proximity in the visual display. Since this field places a premium on pilot response, we felt that the angular accelerations and velocities of the cockpit would be a particularly useful feature in this study.

A requirement for radar-displays simulation is anticipated in connection with research activities involving "combat simulation," the Eagle Missile combination being a good example along with ASW and AEW work.

After surveying the requirements above, it was evident that much of the simulation equipment required was parallel in function as illustrated in Fig. 3. That is, the requirements for a visual presentation of the outside world, the accelerations of the vehicle, the instrumentation, and the radar displays were common to many projects. We decided, therefore, to

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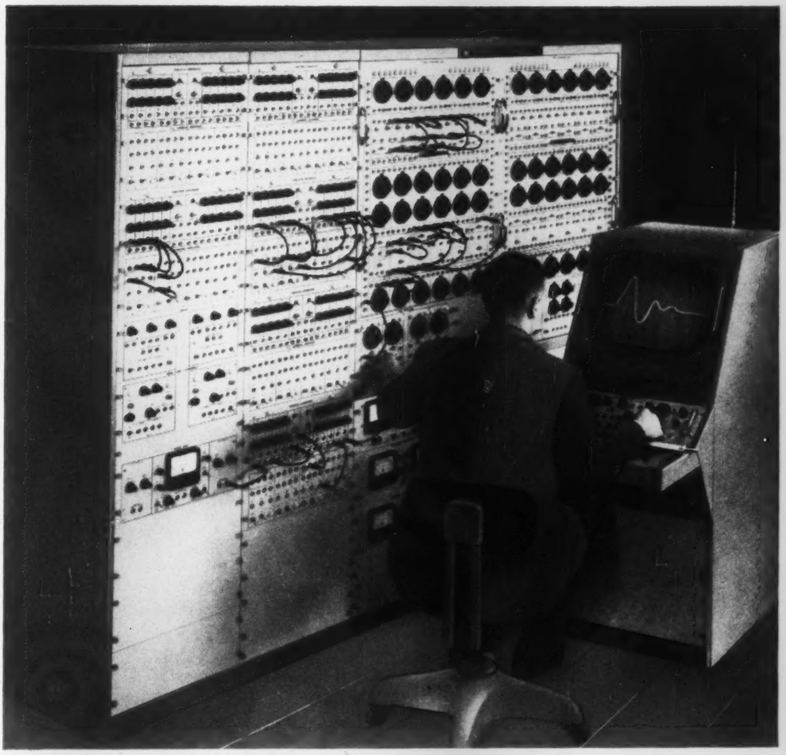
*Tha's *our* touble.—Ed.



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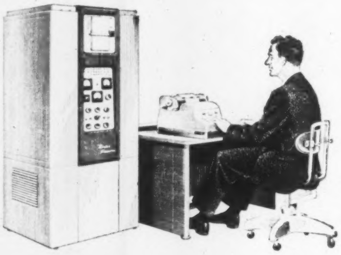

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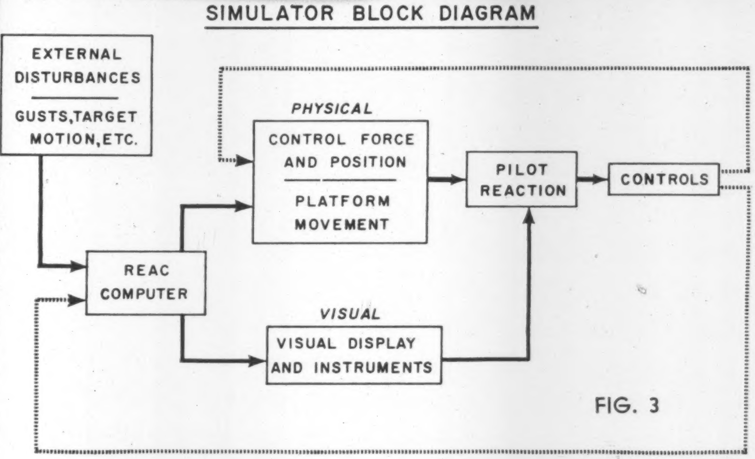
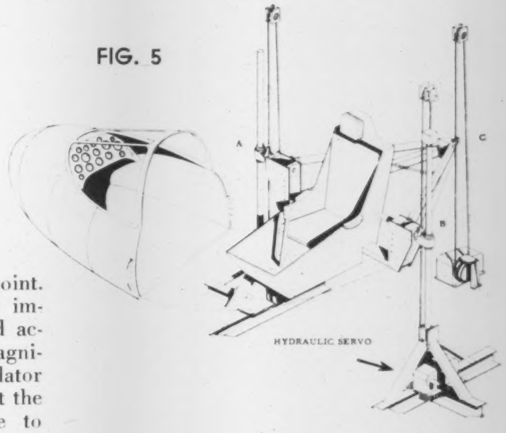


FIG. 3

ROLL	PITCH	GUSTS
ϕm ±30°	θm ±15°	hm .27 ft. 3 cps
$\dot{\phi} m$ 1.6 rad / sec	$\dot{\theta} m$ .82 rad / sec	$\dot{h} m$ 5.1 ft / sec
$\ddot{\phi} m$ 5.2 rad / sec²	$\ddot{\theta} m$ 2.6 rad / sec²	$\ddot{h} m$ 3g
frequency - to .5 cps	frequency - to .5 cps	

FIG. 4 TABLE WEIGHT 1000 lbs. (est.)

FIG. 5



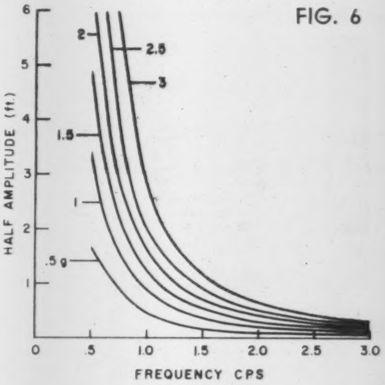


FIG. 6

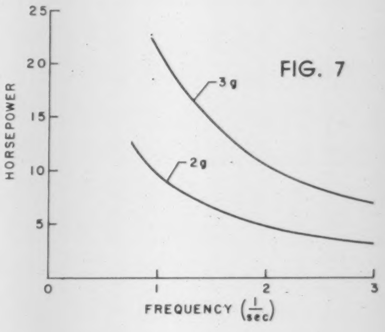


FIG. 7

assemble equipment with a great deal of flexibility built in so that it could be patched together for the desired results. *Dick Kopp* and I made a trip to many simulator installations around the country to gather state-of-the-art information on motion simulators, visual displays, instrumentation, and radar displays.

Motion Simulation

Many different combinations of angular and linear degrees of freedom are being used on motion simulators. Bell Helicopter is having one installed with four degrees of freedom—roll, pitch yaw, and heave. Ryan has two degrees of freedom—pitch and yaw. NACA Ames, two degrees—roll and pitch. NACA Langley, two degrees—pitch and heave; and NADC Johnsville has its centrifuge.* All these simulators of course have mechanical limits to all degrees of freedom. We have chosen a different combination for our work—roll, pitch, and heave.

Fig. 4 gives the specifications on performance to which the motion simulator had to be designed. Fig. 5 is an isometric of the configuration arrived at. It consists of three hydraulic servos driving points A, B, and C. These servos are driven from the outputs of a computer and, in essence, position three points in a plane. With this arrangement the pitch axis can be any place from the mechanical axis A-B to infinity. Pitch is limited from about ± 15° about axis A-B down to an angle subtended by an arc six feet long, depending upon the radius of rotation. In other words, the vertical component of pitch is limited to six feet.

For the purpose of simulation, where the objective is to give a physical cue as to what the aircraft is doing, it is possible to reduce and/or modify these accelerations. Two factors are to be considered at this point. First, it would be mechanically impossible to duplicate a sustained acceleration of any reasonable magnitude by the motion of the simulator platform. Second, we believe that the human body is most sensitive to changes in force of acceleration, and tends to acclimate itself to constant quantities. We feel, therefore, that the following approach would prove most suitable where resulting displacements are beyond the platform's limit. Signals proportional to the accelerations of the aircraft will be fed to the hydraulic servos from the REAC. The resulting velocities will be "washed out" at a rate which is imperceptible to the operator. After reaching zero velocity at some displacement the platform will return slowly to its neutral position. The visual display will be used for steady-state rotations.

High-speed flight at low altitudes poses many problems of control, primarily because of gusts and terrain clearance. This motion simulator includes, in its design, provisions for the reproduction of a range of gust conditions by vertical movement of the platform. With a 1,000-lb load on the simulator, up to 3g accelerations may be produced. Fig. 6 shows the envelope within which the platform will operate. Fig. 7 shows the power required for this motion.

The platform will be capable of any simultaneous combination of the motions described above. A "normal g" simulation device, which was employed successfully in the F11F simulator, will be included in this simulator. This apparatus consists of straps over the shoulders of the pilot which, by pulling him down into the seat, gives the feeling of normal "g's."

The three hydraulic servos consist of three Vickers 3911 series piston-type hydraulic motors with 0.598 cu in/rev displacement. These motors are capable of producing 17.1 hp continuously or 38.5 hp intermittently. These motors drive the load through three 15-1 Ohio Gear Co. reducers. The output of the gear box is a 6"-diameter drum around which is wrapped a ¼" steel cable. This cable goes up and around the top pulley and then is fastened to the moving part of the rig. Three-turn potentiometers are used for position feedback and are geared to the shaft of the top pulley. This allows slippage of the cable on the lower drum without changing the position of the poten-

---

*Which some who have ridden say involves "heave."

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Process Control

by A. J. Young. A "must" for all who have to do with the automatic control of industrial processes, this book combines for the first time the practical "how" and the theoretical "why". Paperbound, 134 pages, 1957 (second printing). **$2.00**

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Introduction to Process Control System Design

by A. J. Young. ". . . provides a simple introduction to the study of process control systems and the factors which influence their design." Aimed particularly at those who (not necessarily instrument specialists) are concerned with automatic control as a tool or technique for increasing plant efficiency. Cloth, illustrated, 398 pages, 1955. **$6.00**

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Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availability (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, illustrated, 1954. **$2.00**

Heat Inertia Problems of Automatic Control of Temperature

by Victor Broida . . . "fictitious mass" concept of heating process unit under automatic control. Paper, 61 pages, 1950. **$1.00**

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by Batcher and Moulic . . . presents electrical and electronic principles applicable to measurement and automatic control. Paper, 244 pages, illustrated, 1946. **$2.00**

Strain Gage Instrumentation

edited by Aronson and Nelson. ". . . a practical text . . . covers, fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated indexed by company, author, and subject, 1958. **$2.00**

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Automatic Control Technology

—Modern Theory and Their Usefulness. Includes 90 advanced papers on control technology as delivered in original language (about $1/2$ of book is in English). Cloth, 9 x 12", 508 pages, 1957. **$25.00**

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Simulation Council—CONT.

tiometer with respect to the platform.

Moog servo valves convert the output of the amplifiers to control the flow of the hydraulic oil. These valves are capable of a 10 gal/min flow rate and have an extremely high response. Two 20 gal/min hydraulic pumps are manifolded together to supply 3000-psi pressure to the valves.

The mechanical part of the platform consists of two 2″ diameter vertical rods which guide linear motion ball bushings, as can be seen in Fig. 5. There is a horizontal sliding rod mounted in two other linear motion ball bushings which makes up the change in length of the main axis of the platform when it is rolled. Two of the hydraulic servos are used to position the outer ends of this axis for roll. The third servo is at the rear, and positions the platform in pitch. This servo is on a pivot so as to be able to follow the arc which the point C describes in pitch.

By using this type of configuration, pure roll and pitch are not obtained. A yaw angle is induced, but this angle is small with small angles of roll and pitch. We feel that this induced yaw will not have detrimental effects on our studies.

We are installing limit stops on the servos which will first cut off the output of the amplifiers and put the REAC into Re-set. If these limits fail, the hydraulic pressure will be shut down by another set of limits. The operator will have a "panic button" available with which he can dump the hydraulic pressure at any time.*

Servo System

We found in the past that we were always fabricating servo equipment to drive different instrumentation, displays, targets, etc. These then had to be wired into the system, which meant that the system was under continuous change and therefore difficult to keep track of. To forestall a repetition of this, a flexible servo system has been designed. It consists of 24 servos, both velocity and positional, with changeable gear trains and output transducers. These are all wired in several relay racks and connected with inters to the simulator platform and the computers. There is a patch panel on the front of the relay cabinets which allows the inputs of both the computer and servo system to be interconnected easily.

The most formidable obstacle to simulation is the visual presentation of the outside world in a ten-foot room.* Many different schemes have been tried, all with limited success. To mention a few—the Point Light Source used primarily with helicopter simulators; the closed-loop TV system using models, such as Link and Curtiss-Wright used for simulated landings; the optical system being developed by Rheem consisting of three 3-dimensional maps representing different altitude ranges and covering an area of 40 square miles; and the contact analog system used by both Bell and Douglas in the ANIP program. Each of these systems has its limitations, and none of them lends itself to use in the general studies for which we plan to use the simulator. We are now studying the problem and have some ideas on a solution, but that is as far as we have gone at present. In the interim we plan to use our old system consisting of a horizon projected on the screen.

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*Beer drinkers note.—Ed.

*This month's "Understatement of the Month" winner.—Ed.

Information (Without Theory)

We received the following *just* too late to include it in the June *Newsletter*:

CALL FOR PAPERS—1959 EASTERN JOINT COMPUTER CONFERENCE

The 1959 EJCC, sponsored by AIEE, ACM, and IRE, will be held at the Statler-Hilton Hotel, Boston, Massachusetts, on December 1, 2, and 3, 1959. Papers will be accepted on any phase of computing. Persons wishing to present papers should submit by August 15, 1959, four copies of a 100 word abstract and a 1,000 word summary. Present plans call for a single session conference, and papers will be limited to a presentation time of 20 minutes followed by a brief discussion period. At the discretion of the program committee, papers of exceptional interest may be allowed a longer period of time for presentation, provided written request by the author is made at the time the abstract and summary are submitted. Abstracts should be suitable for inclusion in the program of the conference. It is requested that summaries be submitted which accurately describe the author's work in order to assist the program committee in selecting papers of greatest merit.

The chairman of the conference will be Mr. F. E. Heart, Lincoln Laboratory, Lexington, Mass., and Mr. H. W. Fuller, Laboratory for Electronics Inc., Boston, Mass., will direct the local arrangements. Exhibit management will be handled by John Leslie Whitlock Associates, Arlington, Virginia. Abstracts and summaries should be sent by August 15, 1959, to J. H. Felker, Chairman, EJCC Program Committee, Bell Telephone Laboratories, Mountain Avenue, Murray Hill, New Jersey, Room 5C-101.

We hope that you have seen and heeded this call for papers elsewhere ere this, because *it is important*.

It is important because there are too many forums for the presentation of papers purported to advance the state of the art of interest to us. The obvious result is that the really worthwhile papers are scattered far and wide in a time-space continuum which makes it impossible for anyone who must do anything else for a living to keep up with them. A corollary of this is that the papers at the meetings we *can* get to are diluted to a discouraging if not actually alarming extent (alarming if these meetings *really* reflect our technical progress).

Realizing this the ACM, AIEE, and IRE joined forces to create the JCC, which has two meetings a year, the EJCC and the WJCC.

Realizing this, the Board of Directors of the Simulation Councils, Inc. decided to cooperate with the JCC to the greatest extent possible to have two, and only two, *really good* computer meetings a year—one on each coast.

Realizing this, I—we—the Simulation Councils, Inc.—implore, beseech, beg, entreat you to save, or create, for the JCC meetings any worthwhile contributions of which you are capable. Your other efforts you may present elsewhere: your plagiarisms to your boss (who might not have had time to read the original); your vague and obscure mathematical ramblings to your *Newsletter* (your Ed. won't understand them either, but he has a convenient circular file); and your half-baked ideas to your colleagues in the Simulation Council meetings. This last is also very important: food for thot must be underdone.

We have been interested in the fast-changing status of our friends in Mid-Century Instrumatic as reflected in News Releases by their hard-working publicity agents Smith, Winters, Mabuchi, Inc.:

"Mid-Century Instrumatic now named Computer Systems, Inc."

"Schlumberger Acquires Interest in Computer Systems, Inc."

"New Process Master Analog Computer Shown by Computer Systems, Inc. at World Petroleum Congress."

Never a dull moment in our chosen (?) field!

Computer Events

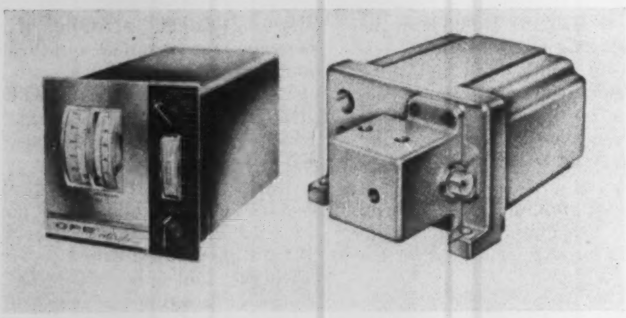
Central Simulation Council

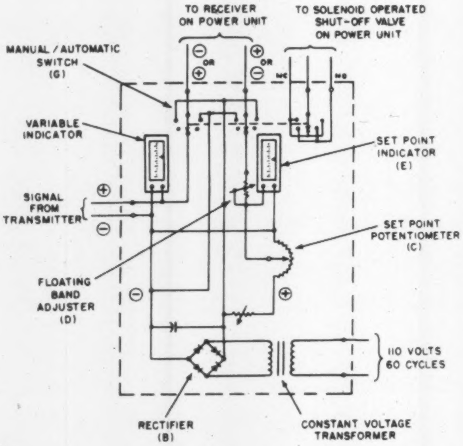
Date: October 1959
Place: McDonnell Aircraft Co., St. Louis, Missouri
Subject: "Computer Environment"

new instruments

FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 1093

Electric Process Control




TO RECEIVER ON POWER UNIT
TO SOLENOID OPERATED SHUT-OFF VALVE ON POWER UNIT
MANUAL / AUTOMATIC SWITCH (G)
OR
OR
NC
NO
VARIABLE INDICATOR
SET POINT INDICATOR (E)
SIGNAL FROM TRANSMITTER
SET POINT POTENTIOMETER (C)
FLOATING BAND ADJUSTER (D)
110 VOLTS 60 CYCLES
RECTIFIER (B)
CONSTANT VOLTAGE TRANSFORMER

New GPE Controls line of electric instruments includes transmitter, indicator-controller, ratio indicator-controller, and an electronic controller, using the existing electrohydraulic valve actuators (Models 684 and 697) as final control elements.

The system is based on a high-output *flow transmitter* whose 5-w (max.) signal makes simple and economic receivers possible without requiring controller amplification. Other features of the flow transmitter include low differential-pressure ranges (adjustable from 0-3" to 0-30" W.C. in Model R776F and from 0-10" to 0-100" W.C. in Model R776D); standard, unshielded transmission lines, usable over long distances; linear output (with square root extracted); highly-reliable integral transistor amplifier; 0-25 vdc output signal; temperature compensation; and accuracy of 1% of range. Heart of the force-balance instruments is a photocell whose output is controlled by a flag, which in turn is positioned by the pressure element.

The low-cost *indicator-controller*, Model R462, with proportional-speed floating control mode, compares the transmitter signal with the set point and sends an error signal to the final control element. Having no electronic tubes, it features set-point adjustment, manual/automatic control, floating-band adjustment, simple calibrating adjustment, and valve-position indicator (optional).

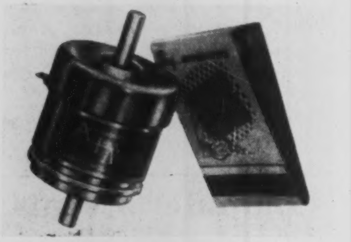
The *ratio controller*, Model R463, also has proportional-speed floating control mode, no tubes, and the same general features as the indicator-controller. It receives signals from two flow transmitters, compares them, and sends an error signal to the valve actuator.

The *electronic controller* incorporates two amplifier tubes (for differential error and for output) and accepts a 0-to-25-v d-c signal from a process-variable transmitter, and a 0-to-25-v d-c manual or cascade set-point signal. The controller features a choice of combinations of proportional, reset, and rate control modes, calibrated in equal logarithmic steps for ease in adjusting to process dynamics. Plug-in components provide circuit flexibility. Output is 1 to 5 ma to the valve positioner. Proportional band is 0 to 1000% in 16 steps; reset is −0.1 to 320 rep/min (std.), and 0.03 to 100 rep/min (slow) in 15 steps and off; rate is −10 to 0.0032 min in 15 steps and off. Process variable and set point are indicated on separate scales; valve position is shown on a third scale.—*GPE Controls, Inc.*, 240 *East Ontario St., Chicago* 11, *Ill.*

CIRCLE 152 ON READER-SERVICE CARD

ELECTROMAGNETIC BRAKE

New completely self-contained Industrial Miniature-B-125 Brake features high torque (40 in-oz) per unit

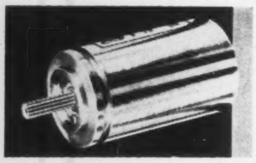


size, quick response, and 0° backlash. No slip rings are required. Available with output shaft out either or both ends.—*Autotronics Inc., Box* 208, *Florissant, Mo.*

CIRCLE 153 ON READER-SERVICE CARD

HIGH-TORQUE SERVO MOTOR

New Type 5002-04 Size 8 Servo Motor developed to BuOrd specs (Mark 23, Mod 1) features 0.35 in-oz

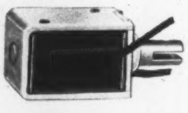


stall torque, 24,700 rad/sec torque to inertia ratio; 26 v fixed phase and 36 v center tapped control phase for transistor applications; 6200 rpm no-load speed and 13-tooth, 120-pitch pinion. Rotor moment of inertia is 10 gm cm^2.—*John Oster Mfg. Co., Avionic Div.*, 1 *Main St., Racine, Wis.*

CIRCLE 154 ON READER-SERVICE CARD

MIDGET D-C SOLENOID

New No. 22 D.C. Miget Solenoid, available for continuous and intermittent duty applications, combines

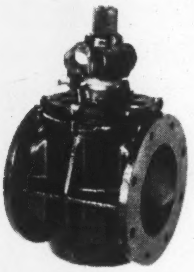


maximum power capacity with extremely small size. Plunger strokes are adjustable from $\frac{1}{32}$" to $\frac{5}{16}$" with a maximum lift of 11 oz, continous duty; 24 oz, intermittent duty. Coil valves range from 6 to 1100 v, dc only.—*Guardian Electric Mfg. Co.*, 1621 *West Walnut St., Chicago* 12, *Ill.*

CIRCLE 155 ON READER-SERVICE CARD

PLASTIC-COATED VALVES

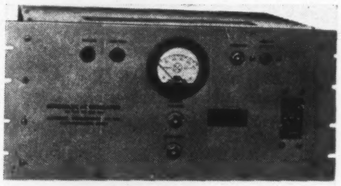
New plastic coating makes DeZurik Eccentric Valves especially suitable for neutral salt solutions, alkalies, alkaline salts, mild acids, and many other services. They are also an economical answer to iron contamination in water distillation, demineralization, and deionization system.—*DeZurik Corp., Sartell, Minn.*



CIRCLE 156 ON READER-SERVICE CARD

LINE VOLTAGE REGULATOR

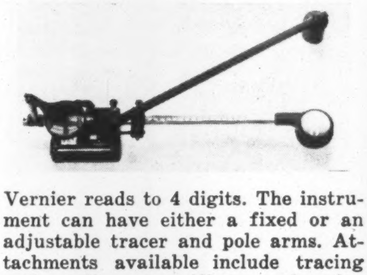
New Line Voltage Regulator for 110- or 220-v lines furnishes regulation of ±1% at 6 kva with a range of ±15 v correction with 115 vac input and ±30 v correction with 230-vac input. The regulator is available in both rack- and wall-mounting styles.—*Electronic Measurements Co., Inc., Eatontown, N. J.*



CIRCLE 157 ON READER-SERVICE CARD

POLAR PLANIMETER

New imported Aristo Polar Planimeter is a compensating unit with completely built-in recording system. Vernier reads to 4 digits. The instrument can have either a fixed or an adjustable tracer and pole arms. Attachments available include tracing and reading magnifiers, and polar disc and pole wagon for conversion to a linear rolling planimeter.—List PI 56E contains details.—*Epic, Inc., 154 Nassau St., New York 38, N. Y.*



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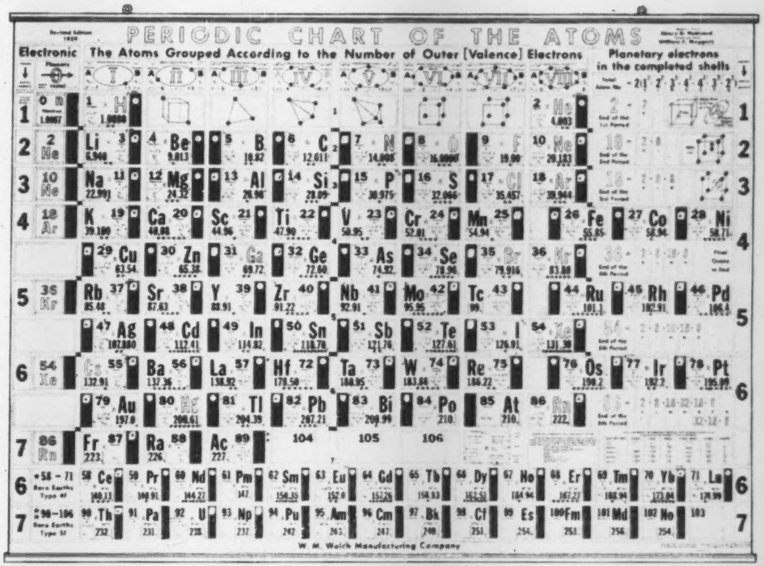
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The Atoms Grouped According to the Number of Outer [Valence] Electrons
W. M. Welch Manufacturing Company

No. 4854.

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ON ALL 102 ELEMENTS THROUGH NOBELIUM

Prepared under the editorial supervision of
DR. WILLIAM F. MEGGERS, NATIONAL BUREAU OF STANDARDS

The Periodic Chart of the Atoms, published exclusively by Welch, is recognized throughout the world as a most authoritative and comprehensive presentation of the principal facts about all known atoms, including artificial transuranic elements recently manufactured.

Its information is sufficiently detailed to serve the most advanced workers in atomic physics, yet it presents basic facts clearly to students of elementary high school chemistry and physics. The characteristics most used in elementary classes, such as the Atomic Number, the Atomic Weight, and the Symbol of each element, are in large display type, the rest being less prominent. Its organization is such that the student is constantly made to visualize each characteristic in its proper place with respect to the whole picture of atomic structure.

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DIGITAL SERVO INDICATOR

New Model 243 Digital Servo Indicator features a 3" synchronized chart drive and simultaneously provides (1) a permanent recording of transducer outputs, and (2) a high-accuracy, digital readout. The Model 243 indicates and records forces, fluid flow, weights, or RPM's which can be converted into a-c or d-c mv. Digital readout accuracy is 0.1%; chart accuracy is ± 1%.—*Gilmore Industries, Inc.,* 13015 *Woodland Ave., Cleveland* 20, *Ohio.*

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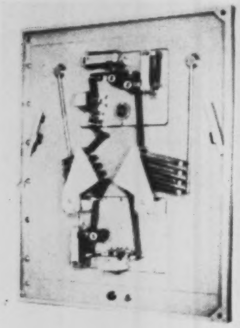
TAPE LOOP TRANSPORT



New Model 3269 family of Digital Magnetic Tape Loop Transports performs data conversions, data rate changing, serial to parallel and parallel to serial conversions, fixed or variable time delay, sorting, and correlations analysis input. One tape drive plate, or two independent tape drive plates with isolating slack loop system, permit flexibility in application. Each tape drive plate may contain one or more capstans.—*Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, N. Y.*

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VISCOSITY CONTROLLER

New Indicator and Indicating Controller for viscosity control work in conjunction with the company's basic measuring elements which operate on the principle of measuring the time required for a piston to fall a given distance through the solution to be measured. Instruments can be furnished with high-low-viscosity alarms. —*Norcross Corp., Dept. N*27, 247 *Newtonville Ave., Newton* 58, *Mass.*

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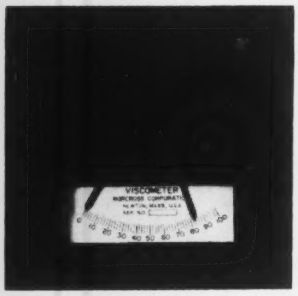
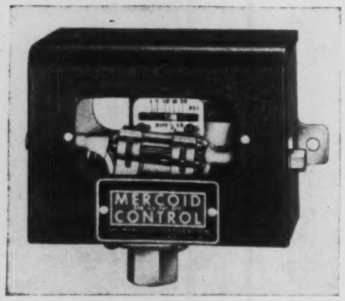


PRESSURE CONTROLLER



New Type AP-153 Pressure Controller of small size (4⅛" x 3⅛" x 2⅞") and light weight (1¾ lb) features external adjustment, repetitive trip point, visible calibrated dial with pointer, and visible hermetically-sealed mercury contact. Operating range is adjustable from 1 to 20 psig. Operating point is easily set by external adjustment. Contacts are SPDT. Recommended for air and gases.—*Mercoid Corp.,* 4201 *Belmont Ave., Chicago* 41, *Ill.*

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Orlando

Georgia
James T. Heagarty & Co.
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Savannah

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Instruments Associates
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Newton Lower Falls 62

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All-South Sales & Engineering Co.
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J. K. Moore Company
3115 Leeland Avenue
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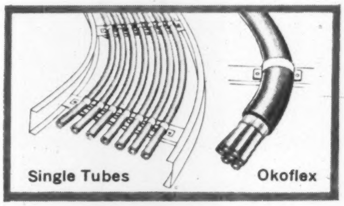
New 3-WAY approach reduces cost of instrument tubing

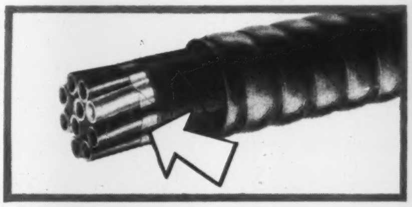
New Okoflex *armored instrument tubing costs less to install than single tubes, yet gives vastly increased resistance to corrosion and mechanical abuse. In addition, **Okoflex costs no more than ordinary multiple instrument tubing.**

Here is the Okoflex three-way approach to reducing your instrument tubing costs:



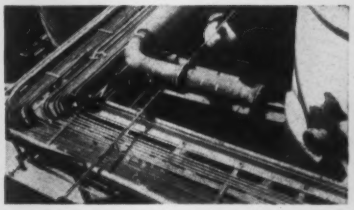
1. Lower installation cost

An Okoflex assembly, consisting of several tubes, takes about the same time to install as a single tube. Existing structures can be used for support, and standard fittings are used for attachment. Armored Okoflex can be "fished" quickly through inaccessible or hazardous locations without fear of tube damage. In addition, Okoflex can be taken down and used over and over again. It is completely salvageable.



2. More durability

Only Okoflex has a Mylar® tape over its core of tubes. This DuPont polyester film provides *extra* protection against both environmental corrosion and galvanic action between the tubes and a metallic covering. One of several Okoflex coverings—each designed for a specific situation—protects the tubes from both physical damage and corrosion. All tubes are tested at not less than 150 psi prior to cabling, and every foot of an Okoflex corrosion-resistant sheath is electrically tested at 4,000 volts to insure that no perforations are present.



3. Tube flattening eliminated

Okoflex cabled tubes—spiraled like strands of rope—can be bent on a small radius without distortion or flattening. Circular in shape, Okoflex' smooth exterior permits easy water and vapor-tight connections with standard fittings. Stresses are distributed evenly to give excellent resistance to mechanical abuse. And on delivery, you'll find that *every* tube is usable . . . none bent or damaged.

* Okoflex is licensed under U.S. Patent No. 2,578,280

For engineering information and prices, contact the Okoflex distributor nearest you. He is listed on the opposite page.

THE OKONITE COMPANY
Subsidiary of Kennecott Copper Corporation
Passaic, New Jersey

OKOFLEX . . . the low cost way to install instrument tubing 6902

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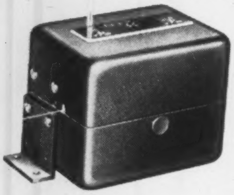
AUDIO ULTRASONIC METER

New 310-B Z-Angle Meter features direct-readings of impedance (ohms), phase angle (degrees), dissipation factor (D), and storage coefficient (Q) in the frequency range of 30 cps to 40 kc. There are internal 60- and 400-cps test signals. Impedance range is from 0.5 to 100,000 ohms; accuracy of impedance magnitude is ± 1%, ±2° of angle up to 20 kc; uses include measurements of amplifiers, electro-acoustic transducers, transmission lines, filters, indicating meters, transformers, etc.—*Acton Labs., Inc., 533 Main St., Acton, Mass.*

CIRCLE 163 ON READER-SERVICE CARD

FORCE AMPLIFIER

New Force Amplifier can be actuated directly by measuring elements for flow, pressure, or temperature, eliminating the need for electronic amplifiers and servos. Completely mechanical device has an operating principle which can be compared to a variable-pitch lead screw. Driving power can be supplied by any external source such as a s-fhp electric motor. Maximum force is developed at the balance or null position. Input forces can be less than 1 gram (0.04 oz) and output is precisely positioned with forces up to 500 grams (18 oz). Linear output motion is identical to input motion within 0.001". With any fixed input position, a 200 gram load change will cause an output error of less than 0.002". Useful travel is 2.0" and full scale travel time is variable from 1 to 20 sec depending upon driving speed.—4-page Product Data Sheet 301-1 gives details.—*American Meter Co., P. O. Box 309, Garland, Texas.*



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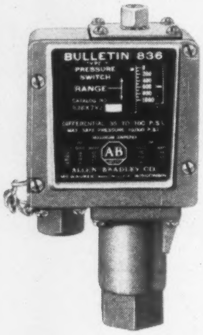
OILTIGHT PRESSURE SWITCH

New Type T oiltight Pressure Switch for machine tool hydraulic systems with die-cast-aluminum enclosure has a calibrated range scale and indicator to show the operating pressure and a visible trip indicator to show when the contacts operate. Range adjustment is mounted on top of enclosure; differential adjustment is accessible from front when cover is removed. Contact block has two isolated circuits with one normally-open and one normally-closed set of double-break, silver alloy contacts. —*Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.*



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THERMAL CONTROLS AND THERMOMETERS

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THE BEST!

A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.

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LOW COST PUMP
for Laboratory Use

- Pumps Liquids, Gases, Slurries
- No stuffing boxes
- No shaft seals
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- Non contaminating

The New "Kinetic Clamp" Pump

Operates by the action of radial arms successively pressing on a loop of flexible tubing. The mechanism clamps one arm against the tubing while the next arm descends to clamping position. Previous clamping arm then raises to permit tubing to assume its normal shape and again fill with liquid being moved.

Standard types of laboratory tubing in a wide range of materials provide a pumping member for almost any liquid, slurry or gas. Tubing can be changed quickly eliminating necessity of cleaning pump. There is no danger of corrosion or contamination.

Pumps can be furnished with motor or for driving from laboratory stirring motor. Write for literature and prices.

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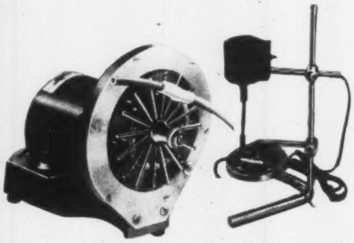

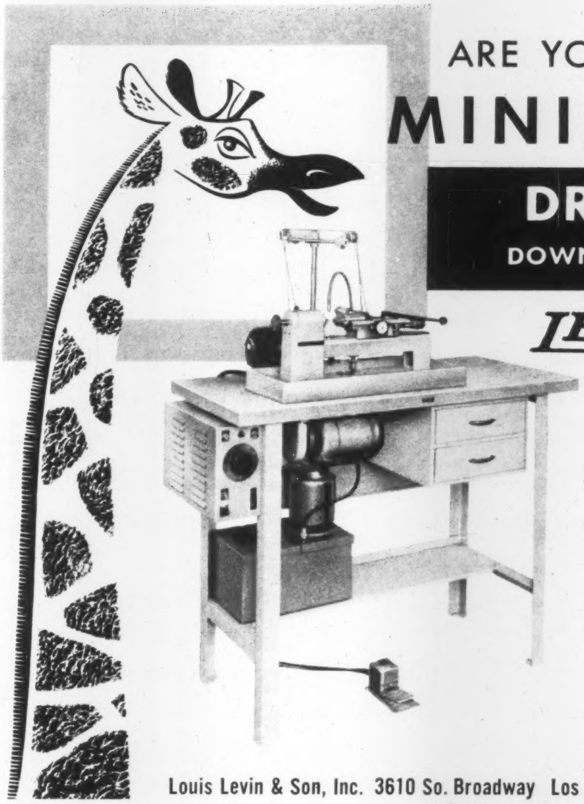

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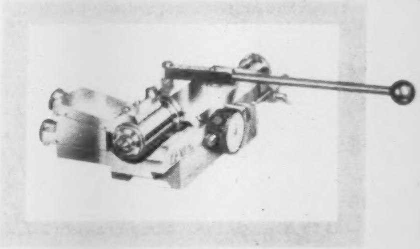
LEVIN® MICRO-DRILLING MACHINE

Designed for the most precise drilling of small holes. The drilling spindle, as well as the head stock spindle, revolves and thus the maximum straightness and concentricity are assured. The feed is so arranged that it does not depend on the operator's sense of feel and the smallest drills may be safely used.



For full details of Drilling Machine and Instrument Lathes send for catalog T.

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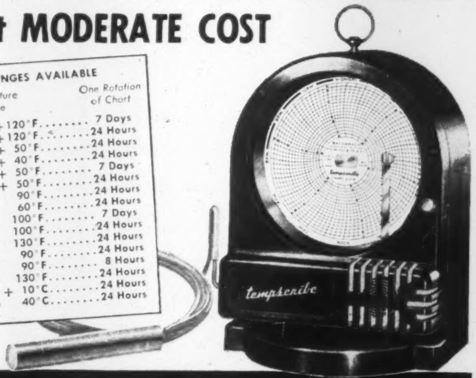
For Accurate TEMPERATURE RECORDS at MODERATE COST

RANGES AVAILABLE

Temperature Range	One Rotation of Chart
—30° to +120°F	7 Days
—30° to +120°F	24 Hours
—30° to + 50°F	24 Hours
—20° to + 40°F	24 Hours
—10° to + 50°F	7 Days
—10° to + 50°F	24 Hours
10° to 90°F	24 Hours
30° to 60°F	24 Hours
40° to 100°F	7 Days
40° to 100°F	24 Hours
50° to 130°F	24 Hours
60° to 90°F	24 Hours
60° to 90°F	8 Hours
70° to 130°F	24 Hours
—25° to + 10°C	24 Hours
5° to 40°C	24 Hours



Use TEMPSCRIBE Recorders

BULB-TYPE (illustrated) — *For recording temperatures at a distance*
BI-METAL TYPE — *For recording temperatures in surrounding air*

- ✓ Portable—easily carried. Can be set on flat surface or hung on wall.
- ✓ Spring-wound instrument-type clock: 3 standard movements—8 hours, 24 hours or 7 days.
- ✓ Instrument measures 4½" x 5½" x 7½"; uses 4¼" diameter charts.
- ✓ Chart graduations easy-to-read; spaced uniformly over full range.
- ✓ Pen and its actuating components are in door. Doors are completely interchangeable to convert to any temperature range, or from bi-metal type to bulb-type.

Also available: (1) Interchangeable door with electro-magnetic armature to record running time of motors, burners, solenoid valves, etc. (2) Two-pen doors for recording temperature and electrical operation on same chart.

Write for Leaflets 786 and 872

BACHARACH INDUSTRIAL INSTRUMENT CO.
200 N. BRADDOCK AVE. • PITTSBURGH 8, PA. T-25

CIRCLE 74 ON READER-SERVICE CARD

Lepel

HIGH FREQUENCY *Induction* HEATING

HARDENING
SOLDERING
ANNEALING
MELTING
BRAZING

LEPEL Electronic Tube GENERATORS —1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters
2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

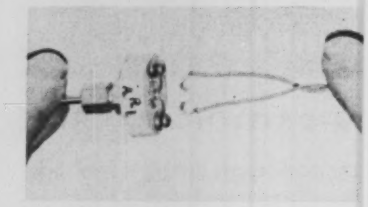
All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

CIRCLE 75 ON READER-SERVICE CARD

THERMOCOUPLE CONNECTOR

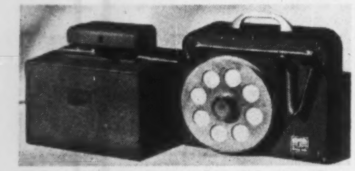
New type of High Temperature Thermocouple Connector (operating range to 1000° F) features direct contact of the thermocouple lead wire to the wire of the thermocouple. Mounted on the end of the thermocouple shaft (no welding is required), it is available for one and two pairs of thermocouples in one shaft. The 2-post connector is designated F-2 and the 4-post connector is designated F-4.—*Aero Research Instrument Co., 315 North Aberdeen St., Chicago 7, Ill.*



CIRCLE 166 ON READER-SERVICE CARD

PHOTOELECTRIC READER

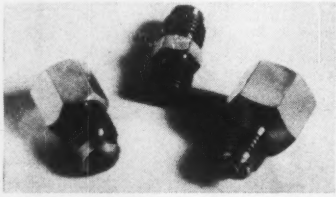
New fully-transistorized, self-contained photoelectric Tape Reader, Model TR5, operates at any speed up to 330 characters/sec and stops on the stop character. It accepts 5-, 7-, or 8-hole tape widths. Reading system uses light from a festoon lamp which is focused by means of a simple lens onto the tape. Underneath tape is a single silicon crystal with 9 photosensitive elements. Output from each of these elements is connected to plug-in printed circuits on which the information is stored in transistor flip-flops whose output signal level changes from + 0.05v to —5v.—*Ferranti Electric Inc., Electronics Div., 95 Madison Ave., Hempstead, L. I., N. Y.*



CIRCLE 167 ON READER-SERVICE CARD

PRESSURE SNUBBER

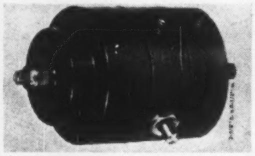
New inexpensive pressure snubber is especially designed for refrigeration and air-conditioning applications; the snubber protects pressure-sensitive instruments against line-induced pulsations or surges. The snubber element, a ¼" disc, fabricated from Type 316 stainless steel contains many fine pores and acts in much the same way as a restriction orifice. Housing in brass or steel is available in ⅛" NPT or ¼" NPT (male or female) by ⅛", ¼", 5/16", or ⅜" tubing, flared or compression type.—*Chemiquip Co., 36 East 10th St., New York, 3, N. Y.*



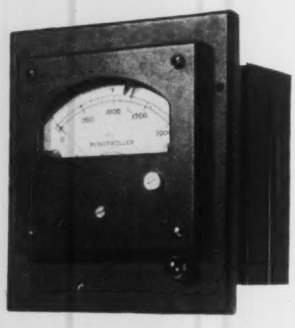
CIRCLE 168 ON READER-SERVICE CARD

PRESSURE SELECTOR

New Mite 71 Pressure Selector automatically selects the higher (or the lower) of two input signals. It can be easily changed from "low" to "high" pressure selection (or reverse) without special tools. Connections are ¼" NPT.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*



CIRCLE 169 ON READER-SERVICE CARD



AUTOMATIC TEMPERATURE CONTROL

Alnor

PYROTROLLER®

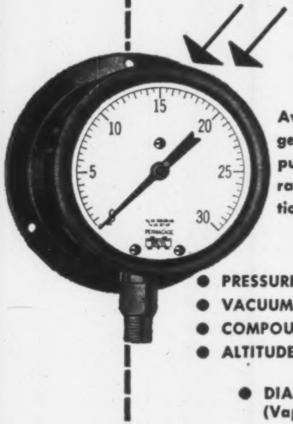
C_m—Mode of control On-Off.
R_T—High-reliability electron tube operates relay on command of temperature indicator.
S_R—Sensitivity of response is such that a temperature change of only .3% of full scale will cause control action.
S^2—Accuracy of rugged movement is plus or minus 1% full scale.
T/W—Torque-to-weight ratio is high of this double-pivoted, moving coil, permanent-magnet type movement. Hardened steel pivots. Phosphor bronze springs. Sapphire bearings.
TC_1—Alnor® Thermocouple Accessories offer you the best engineered control package for all applications from 0-400°F. to 0-3000°F.

$\frac{C_m (T/W^{3/2}) (1+R_T)}{S_R} \times AM + TC_1 =$ Alnor automatic Pyrotroller temperature control.

Get complete details on this compact electronic indication-controlling pyrometer by writing to: Pyrotroller, Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Illinois.

ILLINOIS TESTING LABORATORIES, INC.
420 N. La Salle St., Chicago 10, Illinois

CIRCLE 76 ON READER-SERVICE CARD



MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS

Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

- **PRESSURE**
- **VACUUM**
- **COMPOUND**
- **ALTITUDE**
- **COMBINATION**
- **DIAPHRAGM**
- **HYDRAULIC**
- **AND SPECIAL PURPOSE GAUGES**
- **DIAL THERMOMETERS (Vapor Tension or Bi-Metal)**

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

CIRCLE 77 ON READER-SERVICE CARD

New GAGE GARD JR.

protects sensitive low-pressure instruments

GG gage gard JR
SERIAL
RANGE
SET PRESS
INDUSTRIAL ENGINEERING CORP

Here's *positive* protection for low-pressure-range instruments — incline manometers, draft gauges, electrical pressure switches, ultra-sensitive low-pressure transducers, and many others!

GAGE GARD JR. is applicable to either atmospheric or relative pressure systems. It's available in four ranges, covering the span of −15 PSIG to +85 PSIG. It will withstand after-cutoff pressure up to 300 PSI.

(For higher-range protectors—up to 9,000 PSIG—ask about GG-1 and GG-2.)

GAGE GARD JR. is repeatable. It reopens after sealing at 2% below the cutoff point. You can adjust and reset the cutoff pressure point at any time, or order it factory-set.

Weighs only 11 ounces! Body material is aluminum; diaphragm is buna-S impregnated with nylon.

Write for Bulletin 547G for complete details and prices.

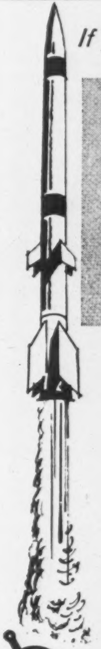
INDUSTRIAL ENGINEERING CORP. IEC

INDUSTRIAL ENGINEERING CORPORATION

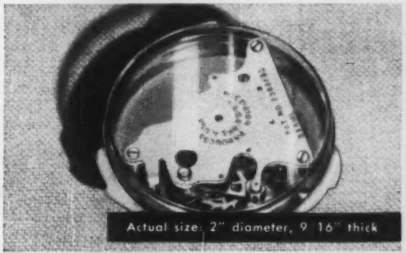
529 E. Woodbine, Louisville 8, Kentucky

Designers, engineers, and manufacturers of hydraulic and electronic test equipment, consoles, panels, etc.

CIRCLE 78 ON READER-SERVICE CARD



If you operate or make timers, use...



Actual size: 2" diameter, 9/16" thick

PRECISION ESCAPEMENTS

Compact PRECISION timing governors (escapements) are especially applicable to installations where space is limited.

Over 800,000 PRECISION built governors are in daily use all over the country in timing devices of many kinds.

Find out about these units or our capacity to make a special one for you.

Write for literature or send us specifications for the governor you need.

PRECISION PRODUCTS, INC.

DESIGNERS AND MANUFACTURERS OF MECHANICAL TIMERS
• INSTRUMENTS • PRECISION PARTS AND ASSEMBLIES

DEPT. IA-3 • 530 SOUTH QUAKER • TULSA 20, OKLAHOMA

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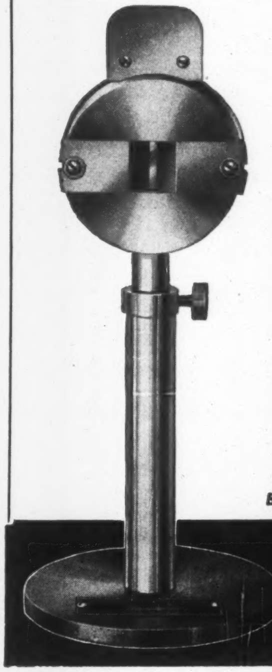


EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

****Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.***

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

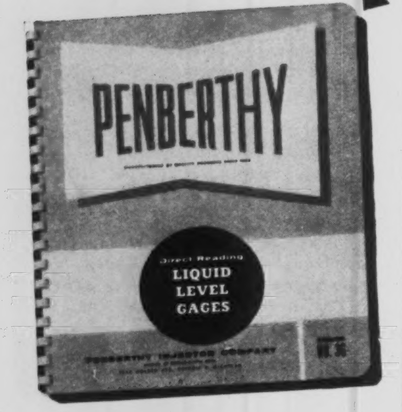
THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

CIRCLE 80 ON READER-SERVICE CARD

GET THIS HANDY GUIDE TO BETTER VALVES AND GAGES



Shows complete line of Penberthy valves and liquid-level gages for power, petroleum, and process industries. Includes technical data, parts, price lists, and accessories such as:

HEATING AND COOLING GAGES... for accurate readings where liquids must be cooled or heated to obtain exact measurement.

INSTRUMENT VALVE... permits gage repair or replacement without shutdowns. Back-seating stem permits repacking under pressure.

FROST PREVENTIVE GAGE... eliminates frost build-up... assures dependable visibility. For industries where frosting interferes with accurate readings.

ILLUMINATORS . . . plastic wedge distributes bright, even light along entire column. Non-glaring... dustproof for perfect illumination.

WELDING PAD GAGES . . . where process conditions require observation windows as integral part of vessel.

PENBERTHY

Dept. A.

Penberthy Manufacturing Company
Division of Buffalo-Eclipse Corporation
1242 Holden Ave., Detroit 2, Mich.
Please send FREE copy of Catalog #36.

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COMPANY________________________

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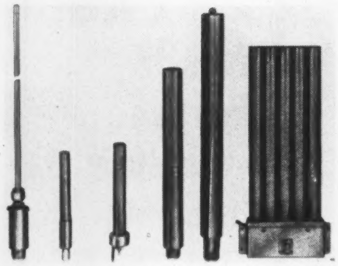
CIRCLE 81 ON READER-SERVICE CARD

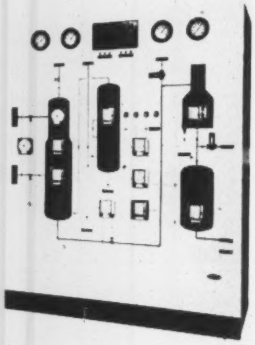
NEUTRON DETECTORS



New line of high-quality, boron trifluoride Neutron Detectors to detect slow neutrons by the B^{10} (n,a) reaction, and fast neutrons by using moderators, offers long plateaus that facilitate discriminating against gamma radiation. They can be used directly with one-millivolt scalers or with any scaler or ratemeter or quarter-volt sensitivity when used in conjunction with a suitable preamplifier. —*Nuclear-Chicago Corp.*, 229 *West Erie St., Chicago* 10, *Ill.*

CIRCLE 170 ON READER-SERVICE CARD

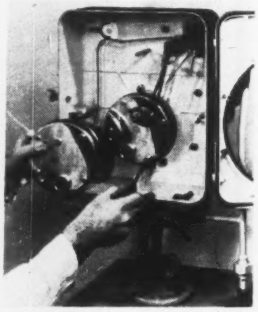
MAGNESIUM CONTROL PANELS



New line of light-weight magnesium Control Room Panel Boards affords substantial savings in time, effort, and cost when installing additional instruments or making other panel alterations in the field, as blow torch cutting or welding during alterations is obviated. Panels can be faced on one or both sides with $\frac{1}{16}$" sheet Formica or Mylar as required.—*Panellit, Inc.*, 7401 *No. Hamlin Ave., Skokie, Ill.*

CIRCLE 171 ON READER-SERVICE CARD

GAS CHART DRIVE



New Gas-Drive, a gas-driven Chart Drive, claimed to operate indefinitely and without attention as long as gas pressure is available. features self-starting mechanism which requires no winding or "priming" of power unit, explosion-proof design, internally-sealed timing mechanism to prevent corrosion and clogging, and accuracy unaffected by supply pressure fluctuations. Operating on 25 psi, and rotating the main arbor once every 24 hours, it delivers 12 in-lb of torque. *Rockwell Manufacturing Co., Meter and Valve Div.*, 400 *North Lexington Ave., Pittsburgh* 8, *Pa.*

CIRCLE 172 ON READER-SERVICE CARD

CENTRAL CONTROL PANEL

New Scope (for Stromberg Central Operations Panel-Electric), a control panel developed to automatically turn on and off lights, heating, and air conditioning, motors, audible signals or electrically-actuated devices from its central location, is ready for electronic operation without special wiring or for synchronous-wired operation with system wiring. When operating on four electronic frequencies, it will automatically control as many as 640 circuits.—*Stromberg Time Corp., Thomaston, Conn.*

CIRCLE 173 ON READER-SERVICE CARD

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

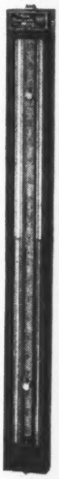
ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBOLT FERRITE
COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 82 ON READER-SERVICE CARD

King MANOMETERS

For Plant and Laboratory



King Manometers are rugged, low-cost instruments of unexcelled accuracy for measuring pressure, vacuum, differential pressure, and pressure-related phenomena. They're available in the following types, in a complete range of sizes:

U-Type Manometers

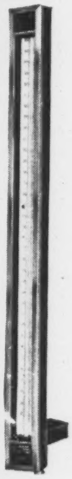
- Single Cleanout
- With 3-Valve Manifold
- Double Cleanout
- Inverted U-Type

Well-Type Manometers

- Low-well
- Barometric-Reading
- Raised-Well
- Flowmeter Type
- Adjustable-Well
- Inclined-Tube

Multi-Tube Manometers

- Individual-Well
- Common-Well
- Photo-Manometers



NEW CATALOG 2008 gives details on these and other models—includes manometer liquids and accessories—explains basic principles. Write—

KING ENGINEERING CORP.
Box 70 • Ann Arbor, Mich.
REPRESENTATIVES IN PRINCIPAL CITIES

CIRCLE 83 ON READER-SERVICE CARD

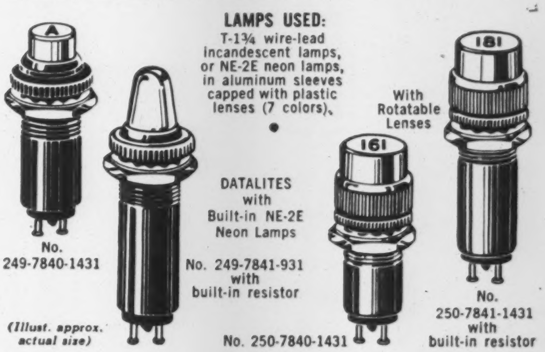
DIALCO
DATALITES
TWIN LAMP ASSEMBLY No. 248-6939-1437
Replaceable Lamp Cartridges
SINGLE LAMP HOLDER No. 7538

In this brochure—complete facts on DIALCO's

DATALITES®

For the Computer-Automation Industries

DATALITES by DIALCO are ultra-miniature Indicator Lights specially designed to meet the critical requirements of the computer-automation fields. Made in 2 basic styles: *Lamp Holders with* DIALCO'S own *replaceable Lamp Cartridges* (see above); or integrated DATALITES *with Built-in Neon Lamps* which are *not replaceable* (see below). Ultra-compact, single units mount in 3/8" clearance hole; the twin-lamp assembly mounts in 3/4" clearance hole.


LAMPS USED:
T-1¾ wire-lead incandescent lamps, or NE-2E neon lamps, in aluminum sleeves capped with plastic lenses (7 colors).
With Rotatable Lenses
DATALITES with Built-in NE-2E Neon Lamps
No. 249-7840-1431
No. 249-7841-931 with built-in resistor
No. 250-7840-1431
No. 250-7841-1431 with built-in resistor
(Illust. approx. actual size)

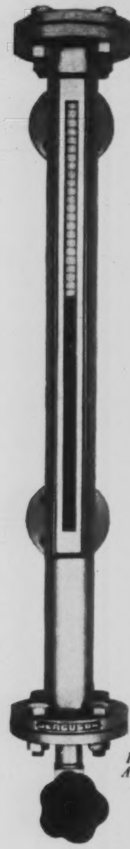
DATALITES have fully insulated terminals and conform to all applicable military specifications. Integrated units are available *with or without built-in resistors.* The cylindrical lenses can be hot-stamped with digits, letters, etc. Complete details in *Brochure L-160.* Send for it now.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights
DIALIGHT
CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600
CIRCLE 84 ON READER-SERVICE CARD

Announcing
the New
Jerguson
MAGNETIC
GAGE
For Liquid Levels



An important advancement in liquid level observation for plants with dangerous explosive or inflammable conditions.

Safety design seals against escaping gases.

Measuring mechanism in stainless steel chamber.

Scale mounted outside chamber; magnetically actuated through chamber wall.

Distinct, accurate level shown in red contrasted with silver above.

Job designed, correlating pressure, temperature, and specific gravity.

Available with electric alarms.

Patent Applied For

Can also be used for interface indication.

Write now for engineering sheet on Jerguson Magnetic Gages.

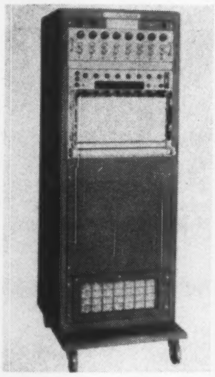
JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices In Major Cities
In Canada: Peacock Bros. Ltd.

CIRCLE 85 ON READER-SERVICE CARD

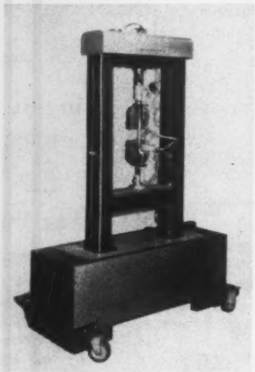
5-VOLT RECORDING SYSTEM



New simplified 6- or 8-channel direct-writing Oscillographic Recording System Model 358-5480, specifically developed for computer readout, telemetry recording, d-c monitoring, and similar applications requiring no preamplification, consists of a 6- or 8-channel control panel for input-signal control and a 6- or 8-channel recorder-amplifier unit. System linearity is 0.5% of full scale (max. chart width 50 divisions); sensitivity is 0.1/division; frequency response is 3 db down at 150 cps at 10 division peak-to-peak amplitude. The system has hysteresis of less than ±0.1 division and gain stability better than 1%.—*Sanborn Co., Industrial Div.*, 175 *Wynam St., Waltham* 54, *Mass.*

CIRCLE 174 ON READER-SERVICE CARD

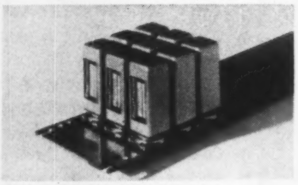
ACCESSORIES FOR RADIOACTIVE TESTING



New design of Models TT-C and TT-B Testers permits the testing assembly to be moved in and out of the hot cell with ease, and features a 50:1 selection of load ranges with a given load cell, and 1000:1 selection of crosshead speeds by remote control. Other features are remote control calibration, remote clutch shift, remote servo-operated dials, remote air-operated grips, and neoprene covers for crosshead screws.—*Instron Engineering Corp.*, 2500 *Washington St., Canton, Mass.*

CIRCLE 175 ON READER-SERVICE CARD

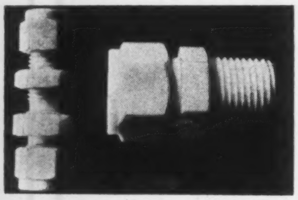
DIGITAL CIRCUIT



New Starter Kit of Series 100 TDC Transistor Digital Circuits comprises a wide selection of different TDC types, applicable to a wide variety of logic networks, including binary and feedback counters.—8-page bulletin contains descriptions of TDC's.—*Epsco, Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*

CIRCLE 176 ON READER-SERVICE CARD

TEFLON TUBE FITTINGS

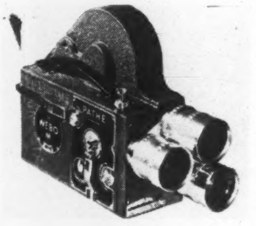


New Swagelok line of tube fittings made of Teflon includes standard fitting shapes in sizes for 1/16" through 1" O. D. tubing. Special sizes and shapes are available also.—*Crawford Fitting Co.*, 884 *East* 140*th St., Cleveland* 10, *Ohio.*

CIRCLE 177 ON READER-SERVICE CARD

CONTINUOUS REFLEX CAMERA

New Pathé "Webo-M" 16-mm Reflex Camera features a continuous-reflex finder system that permits sighting through the shooting lens without loss of brilliance, even when the variable shutter is practically closed.—*Burke & James, Inc.*, 321 *S. Wabash Ave., Chicago* 4, *Ill.*


PATHE
WEBO M

CIRCLE 178 ON READER-SERVICE CARD

DIGITAL PUMP

New Digital Pump or Compressor can be used in combination with recording controllers, analog computers, digital computers, or simple manual remote control stations, direct and/or with suitable conversion equipment. By employing a nominal number of control cylinders and valves and proportioning each cylinder's volumetric displacement to conform to the binary progression, precise incremental discharge control is obtained by programming (sequencing or selecting) each valve to operate to conform with the binary progression.—*Ferguson-Hille & Assoc., Inc.*, 542 *So. Dearborn St., Chicago* 5, *Ill.*

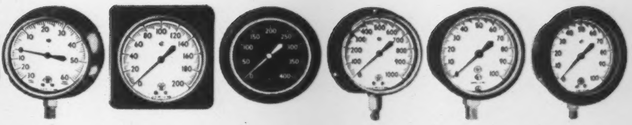
CIRCLE 179 ON READER-SERVICE CARD

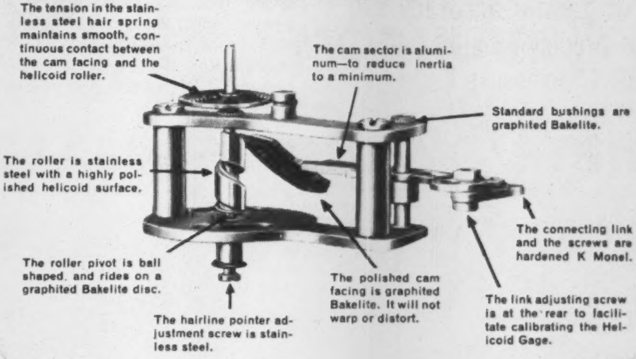
POWER-TEMPERATURE REGULATOR

New SPG5009 Power-Temperature Regulator System to control the power input to an electrically-heated process includes an electronic controller and ignitron firing circuit. By varying the firing angle of the ignitrons the controller proportionally regulates the load power, which is 50 kva for the air-cooled ignitron and 140 kva for the water-cooled type.—*Research Incorporated*, 115 *N. Buchanan, Hopkins, Minn.*

CIRCLE 180 ON READER-SERVICE CARD

ACCO
Helicoid
Gage
U.S.A.




The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869

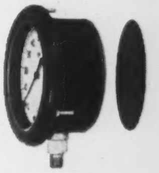
Exclusive Helicoid movement provides...
***Sustained Accuracy*... on the toughest jobs**

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.



NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details

The HELICOID GAGE...

Ask for Catalog DH-65

HELICOID GAGES

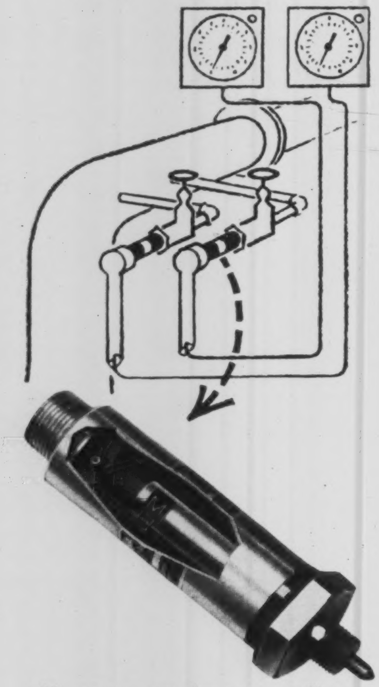
ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 86 ON READER-SERVICE CARD

MEASURING PRESSURE?

For greater accuracy use precision-calibrated SR-4® Pressure Cells



If you are measuring or controlling fluid pressure, you should know these facts about accurate, rugged SR-4® Pressure Cells. Standard accuracy: ±¼% (higher accuracies available for calibration). Calibration does not change with time. Contact fluid directly; require no external piping. Contain no moving parts. Output signal suitable for remote indication, recording or control. Widest pressure range coverage of any commercially-available transducers: 0 PSIA to 100,000 PSIG. Low line, low differential and high frequency models available. Special configurations can be provided.

Write for more information—address Dept. 7-G, and ask for Bulletin 4365

FIRST in force measurement

SR-4 BALDWIN BLH LIMA-HAMILTON

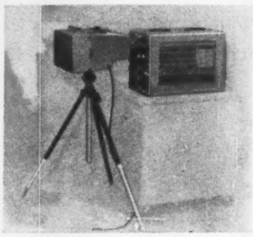
BALDWIN·LIMA·HAMILTON

Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

CIRCLE 87 ON READER-SERVICE CARD

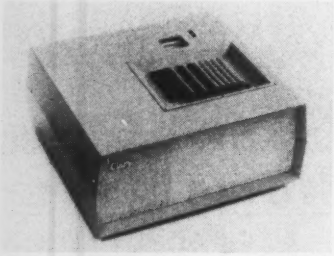
OSCILLOSCOPE CAMERA

New Type C6 Oscilloscope Camera is adaptable to any type of oscilloscope utilizing a 5" tube, and renders a black-and-white photographic record of phenomena displayed on the scope. It incorporates a 1:1 high-speed lens, and two interchangeable gears, one set for a speed of ¼ to 17"/sec the other for 5 to 275"/sec —*Hamilton Watch Co., Hathaway Instrument Div.,* 5800 *East Jewell Ave., Denver* 22, *Colo.*



CIRCLE 181 ON READER-SERVICE CARD

SCANNING PRINTER

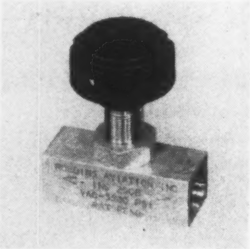


CIRCLE 182 ON READER-SERVICE CARD

New electronic Scanning Printer, Model 1961, which works directly from logical levels has a keyboard for supplemental data entry and 12-digit decoding and printing capacity for electronically controlled data from both decimal and binary-coded decimal sources. Input sources include step switch and electronic digital voltmeters, decimal and BCD shaft position transducers, electronic counters, EPUT meters, step switch banks, relay banks and selector switches.—*Clary Corp., Electronics Div.,* 408 *Junipero St., San Gabriel, Calif.*

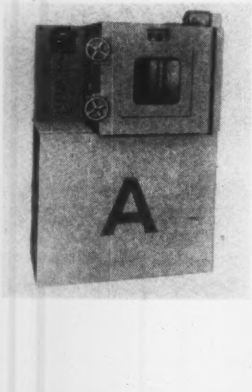
INSTRUMENT VALVES

New INS-Series panel-mounting Instrument Valves, featuring very fine metering characteristics and very low operating torque, are said to be excellent for control of manometers and gages. Valves are available in two sizes (INSI25B with ⅛"-pipe, and INS25OB with ¼"-pipe, female threads) with brass body and 303-stainless-steel spindle barrel and spindle. Working pressures range from absolute vacuum to 3500 psig.—*Robbins Aviation, Inc.,* 2350 *East 38th St., Los Angeles* 58, *Calif.*



CIRCLE 183 ON READER-SERVICE CARD

TEMPERATURE TEST CHAMBER



New Environmental Test Chamber for low-high temperature testing in the range of −100° F to +1000° F utilizes fast-acting liquid CO_2. Starting from ambient, a temperature of −100° F can be reached in less than 3 minutes. Heat dissipation within the chamber is at least 5000 BTU/hour at −100° F.—*Associates Testing Laboratories, Inc., Mfg. Div., Clinton Rd., Caldwell, N. J.*

CIRCLE 184 ON READER-SERVICE CARD

DIGITAL CHRONOMETERS

New line of Digital Chronometers offers direct time readout in edge-lighted numerals 1″ high, plus output contact closures for systems control, printers, and recorders, or total systems programming. Chronometer is offered in three 12-hour models, three 24-hour models, two 100-hour models, and a 1000-hour model.—*Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.*

CHRONOMETER

CIRCLE 185 ON READER-SERVICE CARD

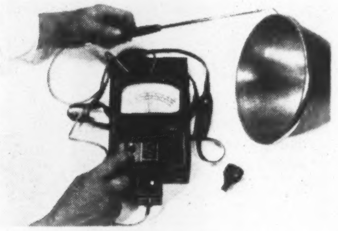
BAND CLAMP

New Wedge Lock Band Clamp, employing a unique design that combines the advantages of ratchet teeth and wedge to prevent slipping, has no metal parts. It is made entirely of non-conductive, non-corrosive nylon. One size band clamp will accommodate cable or wire diameters from ⅛″ to 1¾″. One or more bands can be combined in series to handle larger jobs.—*Weckesser Co., Dept. IT-5, 5701 Northwest Hwy., Chicago 46, Ill.*

CIRCLE 186 ON READER-SERVICE CARD

THERMISTOR THERMOMETERS

New portable Thermophil thermistor-principle Thermometers combine sensitivity in response with durability. Thermistors are stabilized by a unique process, (developed in Belgium) which involves exposing the thermistors to high-frequency sound waves. Response times are 0.72 sec in liquids and 2.2 sec on surfaces. Full-reading responses are 5 and 15 sec, respectively. Standard accuracies are up to ± 0.14°C (or ± 0.25°F). Various instruments cover temperatures from −328 to +845°F (or −200 to +450°C). Readability is ¼° or better on standard models, and down to 0.05° on shorter span instruments. Over 100 different, interchangeable probe designs and 26 instruments are available in the Thermophil line.—*Atkins Technical, Inc., 709 Marion Bldg., Cleveland 13, Ohio.*



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PORTABLE RECORDING SYSTEM

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Model BSA 200
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with Preamplifiers

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PRODUCES PURE WATER of *10,000,000 ohms* ELECTRICAL RESISTANCE

Equipment consists of Barnstead Demineralizer, organic removal cartridge, and mixed-bed cartridge for removal of organic matter and mineral impurities. The Barnstead® MF® Submicron Filter removes particles down to 0.45 micron. The distilled water storage tank is equipped with a Barnstead Ventgard® which purifies the air entering the storage tank. Keeps distilled water pure by removing all air-borne bacteria, dust, gases, mist etc. Re-circulates and re-purifies the distilled water to 10,000,000 ohms electrical resistance. Also removes organic contamination.

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CIRCLE 89 ON READER-SERVICE CARD

IMPEDANCE BRIDGE

New portable Type 1650-A Impedance Bridge for the measurement of inductance and storage factor (Q) of inductors; capacitance and dissipation factor, (D) of capacitors; and a-c and d-c resistance of all types of resistors; features "Orthonull," a new mechanical-ganging device which facilitates measurement of low-Q inductors (or high-D capacitors). —*General Radio Co., West Concord, Mass.*

CIRCLE 188 ON READER-SERVICE CARD

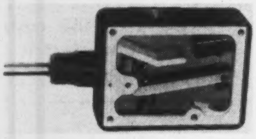
BIMETALLIC THERMOMETERS

New series of bimetallic thermometers, Model 4000, features all-stainless-steel construction (including welds). Back-connected (angle) and bottom-connected (straight form) indicators are calibrated for accuracy of ±1% of range over entire scale. —*Weston Instruments Div., Daystrom, Inc.,* 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

CIRCLE 189 ON READER-SERVICE CARD

COMPACT THERMOSTAT

New Model M-1C Thermostat a rugged, compact unit, has a range of 150 to 600°F. Other ranges up to 1200°F are available. The cast-aluminum weather-proof case is the size of a pack of regular cigarettes, and the differential expansion tube assembly is of stainless steel. Temperature settings are made with the internal adjusting screw shown at the top of picture.—*Burling Instrument Co.,* 16 *River Rd., Chatham, N. J.*



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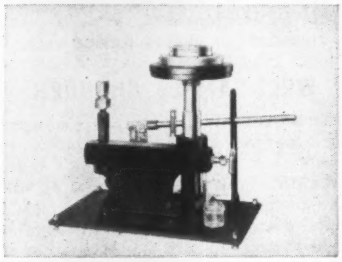
SOLENOID VALVE

New Solenoid Valve, designed to over-ride pneumatic controls of a nuclear reactor being developed for aircraft propulsion, featuring extreme reliability under high ambient temperatures, coupled with small size, light weight, and compact design, is adaptable to all applications in air, liquid, or gas service requiring resistance to high temperatures.—*Alco Valve Co.,* 865 *Kingsland Ave., St. Louis* 5, *Mo.*

CIRCLE 191 ON READER-SERVICE CARD

BI-FLUID PRESSURE TESTER

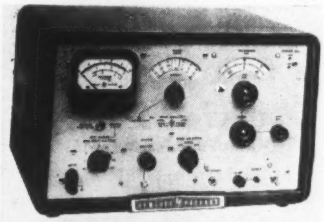
New Type 472 deadweight pressure tester uses pure water as hydraulic fluid entering gage or unit under test, while permitting use of lubricating oils in the piston-cylinder for most accurate, sensitive measurement. Water used is easily removed and never re-used to prevent contamination. Accurate to 0.1%, the BI-FLUID tester is available in capacities from 200 psi to 10,000 psi.—*Amthor Testing Instrument Co., Inc.,* 45-53 *Van Sinderen Ave., Brooklyn* 7, *N. Y.*



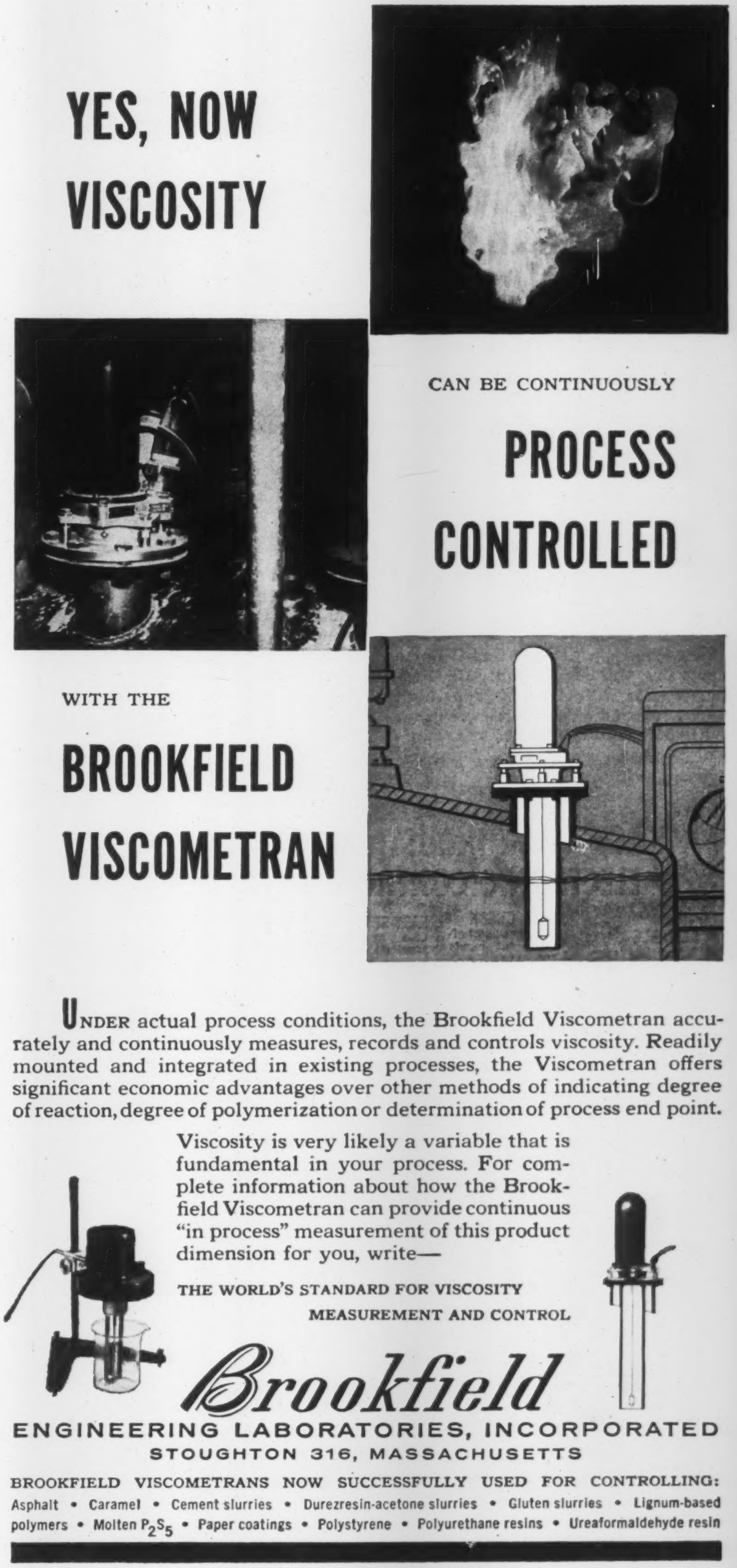
CIRCLE 192 ON READER-SERVICE CARD

WAVE ANALYZER

New completely-transistorized Wave Analyzer,, Model 302A, operating from 20 cps to 50 kc, separates an input signal into its individual components so that the fundamental, harmonics and intermodulation products may be separately measured and evaluated. It may also be used as a narrow-band tuned voltmeter which will read absolute or relative levels. Featuring low power consumption, elimination of warm-up time, and portable operation from an external d-c source as well as from 115/230-v power lines.—*Hewlett-Packard Co.,* 275 *Page Mill Rd., Palo Alto, Calif.*



CIRCLE 193 ON READER-SERVICE CARD


YES, NOW VISCOSITY CAN BE CONTINUOUSLY PROCESS CONTROLLED WITH THE BROOKFIELD VISCOMETRAN

UNDER actual process conditions, the Brookfield Viscometran accurately and continuously measures, records and controls viscosity. Readily mounted and integrated in existing processes, the Viscometran offers significant economic advantages over other methods of indicating degree of reaction, degree of polymerization or determination of process end point.

Viscosity is very likely a variable that is fundamental in your process. For complete information about how the Brookfield Viscometran can provide continuous "in process" measurement of this product dimension for you, write—

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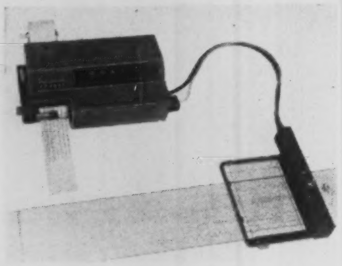
CIRCLE 91 ON READER-SERVICE CARD

DATA REDUCTION

New and basic Automatic Data Reduction Instrument GOAT (Gerber Oscillogram Amplitude Tabulator)



consists of two parts; (1) a stationary printing counter and the necessary servos, placed on the desk; and (2) a hand-held rectangular frame with a fixed and a variable hairline which can be moved in either direction—*Gerber Scientific Instrument Co., 89 Spruce St., Hartford 1, Conn.*

CIRCLE 194 ON READER-SERVICE CARD

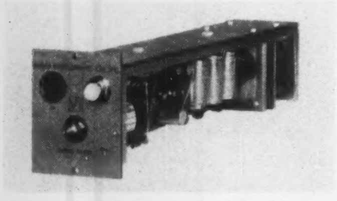
HIGH-PRESSURE REGULATORS

New high pressure Gas-O-Dome regulators, the GD100 and GD200 series, designed primarily for high flow regulation of non-corrosive gases and liquids used in missiles and industrial applications, operate at maximum inlet and outlet pressures up to 6,000 psig. The GD100 series, available with valve and orifice sizes from ⅜" to ¾", with AN tubing or pipe connections, is constructed with forged bronze body, stainless-steel valve and Kel-F seats.—*Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.*

CIRCLE 195 ON READER-SERVICE CARD

D-C POWER SUPPLY

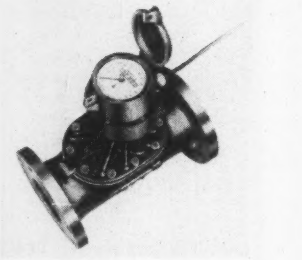
New solid-state regulated D-C Power Supply, Model SR-200E, designed especially for strain gage excitation, features less than 10 mv of noise peak to peak (when measured with a 350 ohm strain gage bridge), and 0.1% regulation, for line-voltage changes from 95 to 135 v. Voltage range from 0 to 15 is continuously variable by means of a 10-turn helical potentiometer. Maximum output current is 200 ma.—*Video Instruments Co., Inc., 3002 Pennsylvania Ave., Santa Monica, Calif.*



CIRCLE 196 ON READER-SERVICE CARD

BATCH CONTROL TOTALIZER

New Batch Control Totalizer Type 252, mounting on any Sparling Mainline meter provides accurate flow measurement by manually setting a pointer on the 4" dial. The accumulated total is shown on the 6-digit straight reading totalizer.—*Sparling Meter Co., 225 North Temple City Blvd., El Monte, Calif.*



CIRCLE 197 ON READER-SERVICE CARD

WELL SAMPLE CHANGER

New Auto/Well Sample Changer, for assaying radioactive samples in liquid solution, employs a high-strength alnico magnet in the sample transport arm which firmly grips a nickel-plated steel cap on the sample vials lifting up a 8 oz. Available in two versions.—*Tracerlab, 1601 Trapelo Rd., Waltham 54, Mass.*

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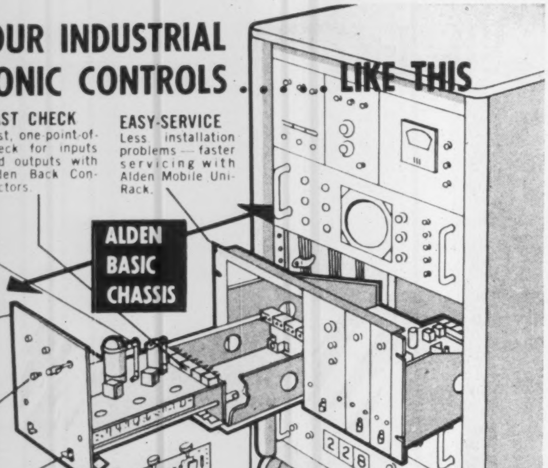
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Tubes and plug-ins won't fall out during use or shipment when secured by Alden plug-in clamps.
FAST CHECK
Fast, one-point-of-check for inputs and outputs with Alden Back Connectors.
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Less installation problems — faster servicing with Alden Mobile Uni-Rack.
ALDEN BASIC CHASSIS
INTERCHANGEABLE
Eliminate costly down-time servicing — make fast replacement with Alden Basic Chassis.
SPOTS TROUBLE
Spot trouble quickly with tiny Alden Tell-tales.
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Chassis lock-in or eject easily by ½ turn of Alden Serve-a-Unit.
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PORTABLE OHMMETERS

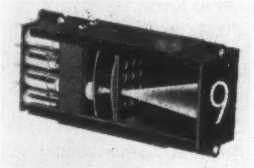
New portable, direct reading Precision Ohmmeter (Model 244 with range of 0.05 to 50,000 ohms, and

Model 246 for 0.01 to 100,000 ohms) are claimed to provide accuracy previously available only with a resistance bridge.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 199 ON READER-SERVICE CARD

DIGITAL DISPLAY

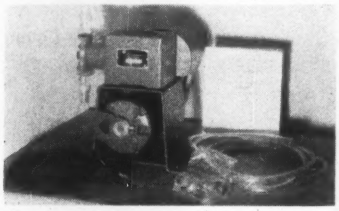
New In-Line Digital Display operates on a rear-projection principle, featuring a condensing lens and a projection lens. The condensing lens contains twelve individual "positions" which have printed on them the desired digit or character. When one of the twelve lamps at the rear of the unit is lighted, it projects the corresponding digit or character on the condensing lens through the projection lens onto the viewing screen.—*Industrial Electronic Engineers Inc., 3973 Lankershim Blvd., North Hollywood, Calif.*



CIRCLE 200 ON READER-SERVICE CARD

POSITIVE DISPLACEMENT PUMP

New, electrically-driven, positive-displacement Chemical Proportioning Pump, Model 1210 Chem-O-Feeder, features a corrosion-resistant transparent plastic head, Hypalon diaphragm and check valves, and a straight-through flow design.—*B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.*



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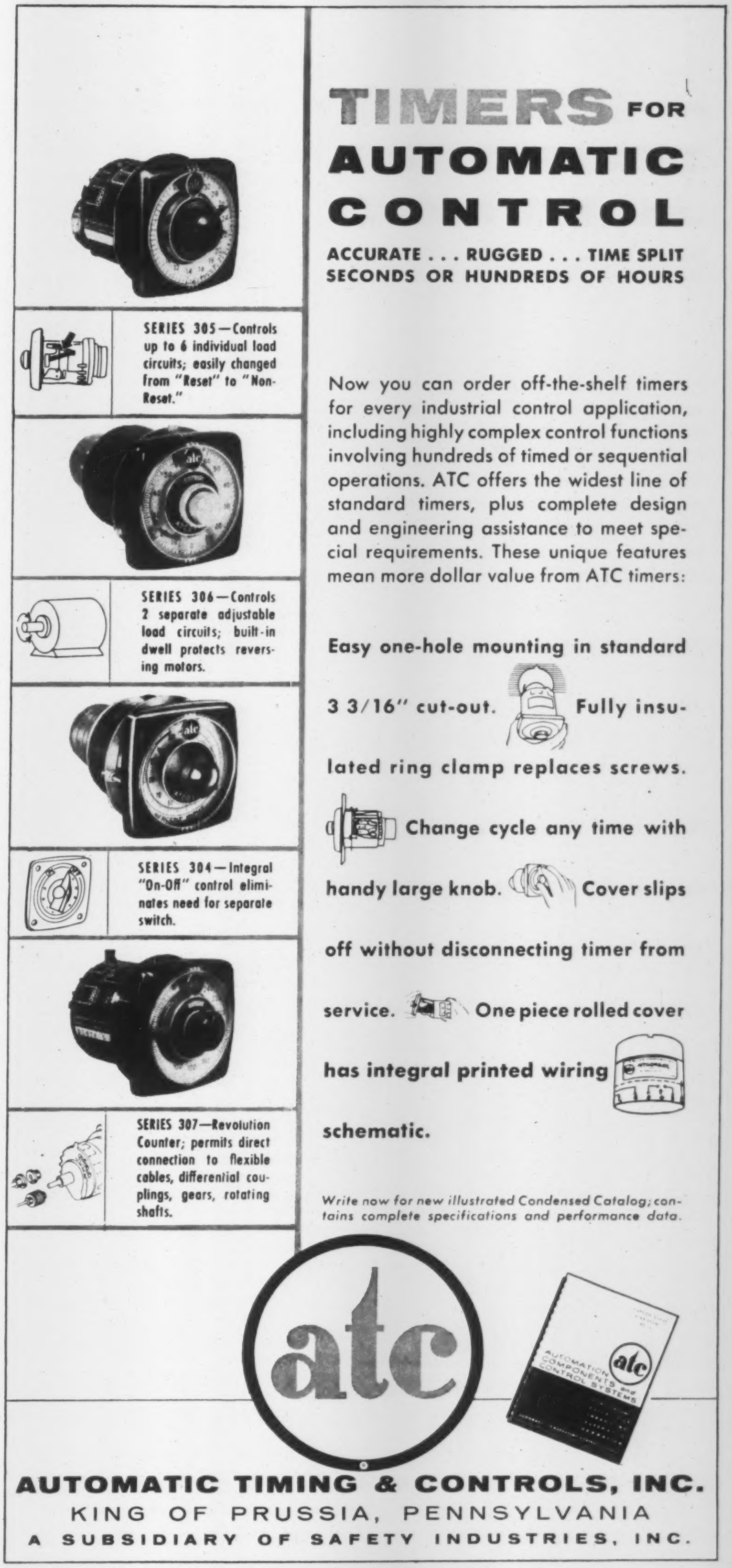

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SERIES 305—Controls up to 6 individual load circuits; easily changed from "Reset" to "Non-Reset."

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Now you can order off-the-shelf timers for every industrial control application, including highly complex control functions involving hundreds of timed or sequential operations. ATC offers the widest line of standard timers, plus complete design and engineering assistance to meet special requirements. These unique features mean more dollar value from ATC timers:

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KING OF PRUSSIA, PENNSYLVANIA
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CIRCLE 93 ON READER-SERVICE CARD

ADAMS FACT FILE #3

INSTRUMENT AIR

Clean Dry Air Supply Will Reduce Production Down-Time . . . Instrument Maintenance . . .

Wet, dirty compressed air has no place in the process industries. In instrument air supply lines it can cause havoc. Whether it be motor air in a control circuit or supply air to the control panel, absolutely clean dry air is vital. Moisture elimination is the major consideration in providing suitable air for instrument and control systems.

Since most plant compressors in use today are oil lubricated, a finite amount of oil is present with the water vapor in the discharge. This carry-over condenses as an oil-water emulsion which often causes serious fouling of instrument components. To eliminate this oil-moisture condensate in the air lines, it is necessary to remove it before it reaches the distribution system. This is done by cooling the air before the receiver. It is advisable to cool well below the ambient conditions to provide the lowest possible humidity at the instrument panel or control units.

Two Stage System Design for Economy

The ideal method to achieve high quality air is a two-step operation.

1—An Adams Aftercooler . . . providing 2° F. cooling . . . and Cyclone Separator installed between the compressor and receiver to remove the bulk of moisture carry-over.

2 — A chemical dryer installed down stream to provide the polishing action necessary for the desired minimum humidity.

Thus, the bulk of water . . . 90% . . . is removed by the Aftercooler-Separator using plant water for cooling. A minimum moisture load is then left to be removed by more expensive methods. Under normal circumstances, all of the oil present in the compressor discharge will be removed in the Aftercooler-Separator. Fouling of the chemical unit is then virtually eliminated.

Poro-Stone Air Filter at Panel Provides Dirt-Free Control Air . . .

In spite of the efficiency of the Adams Aftercooler and Separator, there still will be some dust and dirt present in the instrument air system. That's why it is advisable to install an Adams Poro-Stone Air Filter in the line just before the control panel.

Separation by the Adams unit is in two stages — centrifugal and diffusion. Centrifugal force throws the foreign matter to the walls of the filter body where it is trapped in slots and drained. Remaining particulate matter is removed as the air passes through the pores of the Poro-Stone element.

This final protection for your instruments will minimize control system failures and process down-time. Instrument maintenance will be sharply reduced.

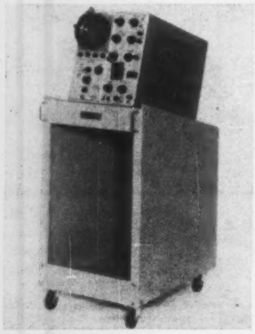
Literature Will Help Air System Design

For further information on how the complete line of Adams air equipment can help you provide a foolproof instrument air supply, write today for your copy of Bulletin No. 712 on Aftercoolers and Separators and Bulletin No. 117 on Poro-Stone Air Filters to the R. P. Adams Company, Inc., 265 East Park Drive, Buffalo 17, New York.

CIRCLE 94 ON READER-SERVICE CARD

SCOPE CART

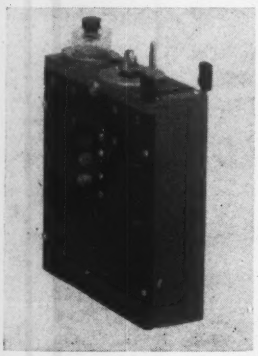
New Model 20-4 Scope Cart provides ample cabinet space for auxiliary equipment and is constructed with a 15° slanted top that brings scope screen and adjustments within easy reach of personnel.—*Northeastern Engineering, Inc., 25 South Bedford St., Manchester, N. H.*



CIRCLE 202 ON READER-SERVICE CARD

TRANSISTORIZED GALVANOMETER

New Model G3 Transistorized Galvanometer, providing current gains up to 1500 and voltage gains up to 10 with an input impedance range from 200 to 1000 ohms and a linearity of ±1.5% of full scale, is especially suited for driving heated stylus as well as the ink-writing pen and electric stylus.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*



CIRCLE 203 ON READER-SERVICE CARD

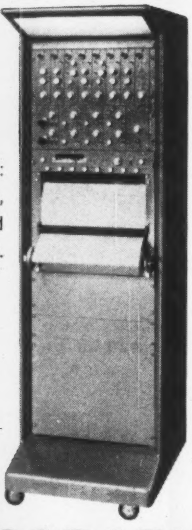
TRACE GAS ANALYZER

New Billion-Aire Trace Gas Analyzer is based on continuous ionization from an alpha source which makes measurement of a large number of gases in parts-per-billon concentrations possible. Applications include detecting trace contaminants in petroleum, petrochemicals, chemicals, drugs, and certain steel metallurgical processes.—*Mine Safety Appliances Co., 201 North Braddock Ave., Pittsburgh 8, Pa.*

CIRCLE 204 ON READER-SERVICE CARD

OFFNER

All Transistor

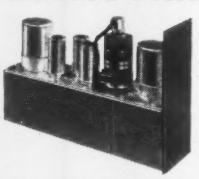


Models available: 1 to 19 channels, console, rack, and portable assemblies.

TYPE R DYNOGRAPH

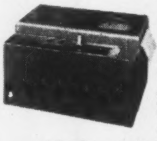
A direct-writing oscillograph with unmatched features of superiority! Whatever your application for direct-writing recording, the Offner Type R All Transistor Dynograph will do your job *better* and more *easily*. Write on your letterhead for literature and complete specifications.

TYPE 190 *Differential* DATA AMPLIFIER



Zero-drift d-c amplifier with 1/100% accuracy. Linearity of better than 0.05%. Gain stability of 0.01%. Ripple of less than 0.1%. Infinite rejection of common d-c signals. Rapid response to step input. Ambient range −67°F to 170°F. Ask for Bulletin 572.

Type 542 Two-Channel DYNOGRAPH



Rapid response, high sensitivity, stability, compact construction, economical price—all features that make this all transistor, 2 channel unit ideal as a test instrument . . . practical for use at every laboratory bench. Ask for Bulletin 181.

OFFNER ELECTRONICS

3910 River Road, Schiller Park, Ill.

(Suburb of Chicago)

Bulletin-572—Circle 95 on Reader-Service Card

Bulletin-181—Circle 96 on Reader-Service Card

No. 1 SPACE STRETCHER

"Inner space" problems are sometimes more baffling to engineers, architects and contractors than those concerned with "outer space."

That needed inch or two amid the usual maze of pipe, conduit, tube and cable is worth its size in gold!

Where space is a factor, that's the place for Weksler ADJUST-ANGLE* Thermometers. These versatile instruments, supplied in four case sizes, meet every installation requirement. The exclusive Weksler ADJUST-ANGLE feature permits positioning of stem or case to fit any space.

MORE THAN A HUNDRED THOUSAND ADJUST-ANGLE INSTALLATIONS!

Write for complete information.

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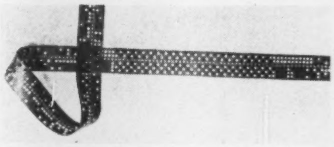
WEKSLER INSTRUMENTS CORP.
FREEPORT, L. I., NEW YORK
INDICATING AND RECORDING INSTRUMENTS
FOR TEMPERATURE, PRESSURE AND HUMIDITY

CIRCLE 97 ON READER-SERVICE CARD

VULCANIZED-FIBRE TAPE

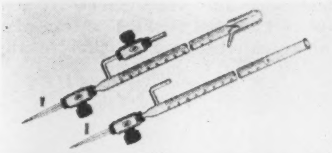
New 0.005"-thick, high-strength Peerless Control Tape, designed for use on tape-controlled automatic programming equipment such as electronic typing calculators and automated fabricating machinery, combines high tensile and bending strength with flexibility. It has a tensile strength of better than 6000 psi, high density, low porosity, excellent abrasion resistance and is easily punched.—*National Vulcanized Fibre Co.,* 1058 *Beech St., Wilmington* 99, *Del.*



CIRCLE 205 ON READER-SERVICE CARD

NEEDLE-VALVE BURETS

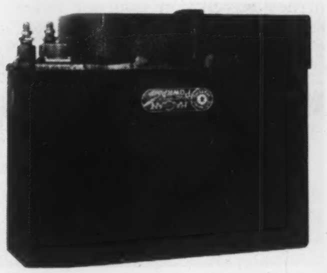
New Manostat Needle Valve Burets, made in all sizes from macro to micro, have now sidearms and absolute zero. Improved Teflon-and-glass needle valves completely eliminate the possibility of stopcock breakage. Liquid comes in contact only with Teflon and glass. Ranges are from 10 ml to 100 ml and from 0.5 ml to 5 ml, respectively.—*Emil Greiner Co.* 20-26 *North Moore St., New York* 13, *N. Y.*



CIRCLE 206 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS

New PowrAmp A-2 Pressure Transducer series now is available in a lower, more sensitive full-scale range of 0-1.5 (minimum) and 0-3.8 (maximum) psig or psia at operating pressures up to 20 psig. Other models function at ranges as great as 0-2000 psi with maximum allowable operating pressures of 3000 psig. —*Hagan Chemicals and Controls, Inc., Controls Div., Box* 1346, *Pittsburgh* 30, *Pa.*



CIRCLE 207 ON READER-SERVICE CARD

PF

FLEXIBLE TUBING
Made from
TEFLON*

For...

HYDRAULIC HOSE, BUSHINGS, CABLE SHEATHING, GROMMETS, ELECTRICAL BARRIERS, HOT CORROSIVE LIQUIDS OR STEAM LINES

And Similar Applications Where Only PF TEFLON* Can Do The Job

PROPERTIES

- complete chemical inertness
- lowest coefficient of friction of any solid material
- very low permeability
- widest service temperature of any plastic (-450°F to +500°F)
- easily cleaned and sterilized without deterioration

Pa. F. flexible tubing is available in a full range of colors and sizes. Our extrusion techniques yield maximum service flexibility and all sizes are carefully inspected and controlled dimensionally.

Write, wire or 'phone for additional details, competent engineering assistance and prompt attention to special sizes and walls. Pressure testing and certification upon request.

PENNSYLVANIA FLUOROCARBON CO., INC.
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TWX PH 252

*"Teflon"—DuPont trade name for Tetrafluoroethylene resin

CIRCLE 98 ON READER-SERVICE CARD

MEASURE FUEL LEVEL WITH MICROMETER ACCURACY!

ACOUSTICA ULTRASONIC continuous gauges and liquid level switches are unequaled for the measurement and control of LOX, kerosene, nitric acid and exotic fuel. Accurate up to 1/64 inch . . . unaffected by liquid variables . . . operate instantaneously . . . consume infinitesimal power . . . no spark or radiation hazard. Now integrated in major military propellant utilization and liquid control systems. Expert Acoustica engineers can help you with your gauging problems. Send for further information.

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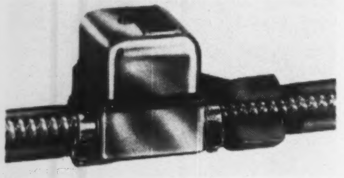
CIRCLE 99 ON READER-SERVICE CARD

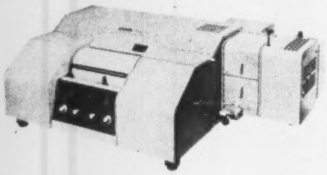
FLUID FLOW MOTOR CONTROL



New Fluid Flow Motor Controller, Model 27, can protect a large number of hydraulic systems having components which depend on minimum fluid flow rate for lubrication, cooling, etc. It is designed primarily as a pumping-unit protection switch. It features a unique time delay which allows fluid to start up and attain normal flow rate before taking over control of the electrical circuit. Maximum flow is 12.5 gpm, minimum flow 0.33 gpm.—*Payne Engineering Co., Pine Hall, N. C.*

CIRCLE 208 ON READER-SERVICE CARD

SPECTROPHOTOMETER ACCESSORY



New Specular Reflectance Attachment for Model 4000-A spectrophotometer can be used to analyze any flat surface which forms a reflective image. It consists of a platform on which three mirrors are mounted and adjusted so that the sample beam will strike the sample at approximately a 20° incidence.—*Perkin-Elmer Corp., Instrument Div., Norwalk, Conn.*

CIRCLE 209 ON READER-SERVICE CARD

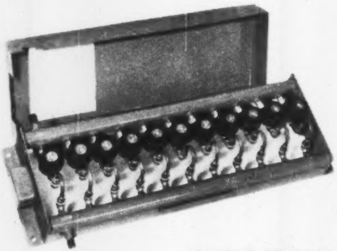
REVOLUTION COUNTER

New small 4-digit, knob-reset, add-subtract Revolution Counter features tamper-resistant design. Top-coming shaft revolutions add 10 counts, reverse revolutions subtract 10 with speeds to 12,000 cpm. One complete turn of knob resets to zero.—*PIC Automation Controls Div., General Controls Co., 8062B McCormick Blvd., Skokie, Ill.*

CIRCLE 210 ON READER-SERVICE CARD

DIGITAL FINAL CONTROL ELEMENTS

- Digital Control Valves
- Digital Regulators
- Digital Actuators
- Digital Pumps & Compressors



PATENT PENDING

DIGITAL CONTROL VALVE

A number of these valves are in service operating directly from Digital Computers, Flow Rate Range 0-2048 cc/m in 1cc/m Increments.

- Operates Directly From Digital Computers without any conversion Equipment.
- Perfect Repeatability and Stability.
- Precision Accuracy
- Instantaneous Response Throughout Range.
- No Complex Servo Devices or Adjustments Required.

FERGUSON, HILLE & ASSOC. INC.
542 S. DEARBORN ST.
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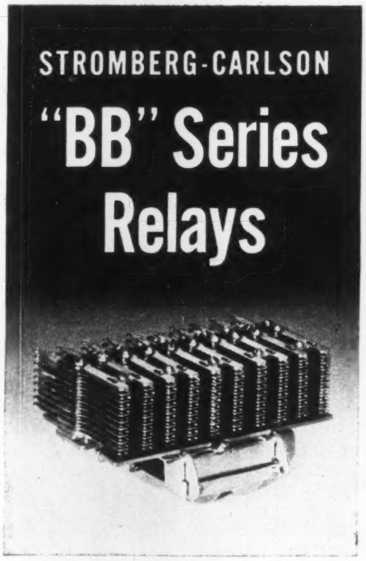
CIRCLE 100 ON READER-SERVICE CARD


STROMBERG-CARLSON

"BB" Series Relays

For your automation ...computing...control circuit applications... "Telephone Quality" at an ordinary price

To meet your needs for precision and durability in automation, computing and control circuitry, this relay provides *telephone quality* at an ordinary price.

The "BB" Series Relay accommodates up to 100 Form A spring combinations. It incorporates such important advantages as twin contacts, knife-edge pivot and special frame-armature construction. Like all Stromberg-Carlson relays, it is built to operate under extreme ranges of temperature and humidity. *Prompt delivery is available on all orders.*

This catalogue will give you complete technical details and specifications. We will gladly send you a free copy on request. Please ask for Catalogue T-5000R.

S-C

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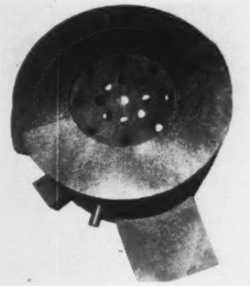
TELECOMMUNICATION INDUSTRIAL SALES
113 CARLSON ROAD, ROCHESTER 3, N.Y.
CIRCLE 101 ON READER-SERVICE CARD

MAGNETIC SHIELD

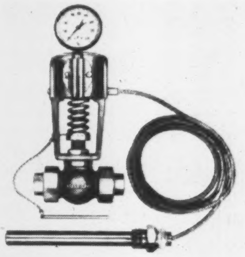
New non-shock-sensitive, non-retentive Co-Netic Netic Magnetic Shield for shaker tables offers accurate evaluation of the function of the apparatus being tested under dynamic conditions by diverting the magnetic fields generated during operation of the shaker.—*Magnetic Shield Div., Perfection Mica Co.,* 1322 *N. Elston Ave., Chicago 22, Ill.*



CIRCLE 211 ON READER-SERVICE CARD

TEMPERATURE REGULATOR

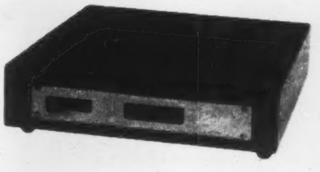
New self-operated Temperature Regulator has proportional control action. Corrective stroke begins with less than 0.1° change at the bulb. The valve stem is sealed by a friction-free bellows. The extra-long preflexed adjusting spring has a low spring rate. —*Manning, Maxwell & Moore, Inc., Stratford, Conn.*



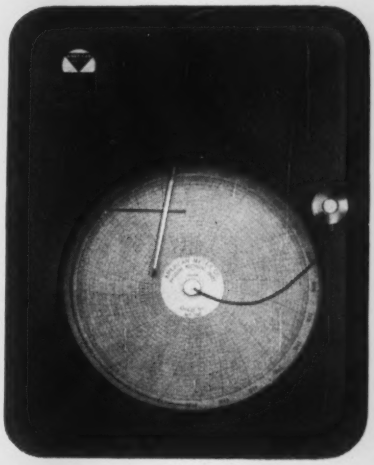
CIRCLE 212 ON READER-SERVICE CARD

PRECISE ANGLE INDICATOR

New Precise Angle Indicator is a complete servo system for numerical presentation of angular positions. Complete unit consists of the indicator, a motor, and a servo amplifier. The standard indicator, CO 2 721 011A, used with a 26-v synchro transmitter, is a representative type among a number of variations and modifications that are available.—*Kearfott Co., Inc.,* 1500 *Main Ave., Clifton, N. J.*



CIRCLE 213 ON READER-SERVICE CARD



AMERICAN®

PRESSURE and TEMPERATURE RECORDERS

American® single and two-pen *Pressure Recorders* for pressures from 30 inches vacuum to 10,000 psi.

- Pressure elements individually calibrated over full range.
- Variety of chart drives available.
- Helical elements of different ranges are interchangeable.
- Stainless steel pen arms with span and linearity adjustments.
- Aluminum dust and moisture-proof case.

American® *Temperature Recorders* for an accurate record of flowing temperatures.

- No ambient temperature errors.
- High sensitivity and torque—fast speed of response.
- Standard 0-150°F. range. Other ranges available by request.
- 24-hour mechanical or 110-v. 60-cy. electric chart drives.

Ask for Bulletins 400 and 408

AMERICAN® METER COMPANY
INCORPORATED (ESTABLISHED 1836)
General Offices: Philadelphia 16, Pa.
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CIRCLE 102 ON READER-SERVICE CARD

SCHLUMBERGER LTD. has acquired an 80% stock

First choice of the rocket and missile industry...

Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges...
because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

MARSH Needle Throttling Valves...
because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

MARSH Dial Thermometers...
because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

MARSH

New catalog covers all details

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 42, Skokie, Ill.**
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

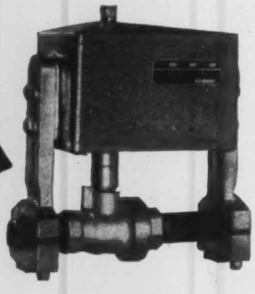
CIRCLE 103 ON READER-SERVICE CARD

Compact High Torque Control!

LOW ORIGINAL COST!
EASY INSTALLATION!

Quickly Installed on Existing Valves Without Disturbing Piping.

R & A Electric Ball or Plug Valve Actuator



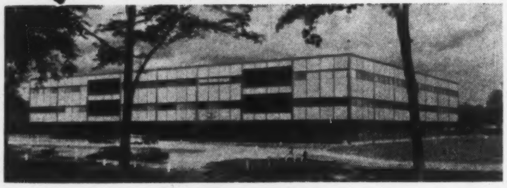
Provides positive automatic control at any distance, yet allows manual over-ride in event of power failure. Standard unit 110 volt 60 cycle AC. Stock models: 325, 650, 1200, 2400 in. lbs. Universal mounting bracket for various ranges of pipe sizes. Explosion-proof models; higher torque models; units for other AC and DC voltages and frequencies available on request.

FOR PRICE LIST AND DESCRIPTIVE MATERIAL, WRITE OR CALL

R & A MACHINE CO., Inc.
100 GROVE ST. WORCESTER 5, MASS.

CIRCLE 104 ON READER-SERVICE CARD

new plants and mergers



IBM recently dedicated a new four-million dollar education center on a five-acre tract next to its manufacturing plant near White Plains.

ENGELHARD INDUSTRIES, INC. was honored by New Jersey's *Governor Robert B. Meyner* who dedicated the new million-dollar research and development lab for the world's largest precious metals refiner and fabricator.

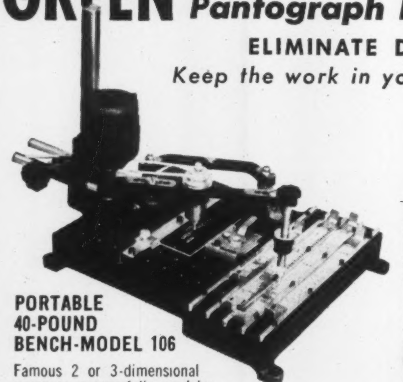
JOHN CHATILLON & SONS, Spring Div., has moved to a larger plant at 48 Franklin St., New York 13. The Scale and Instrument Div. remains at 85 Cliff St., New York 38.

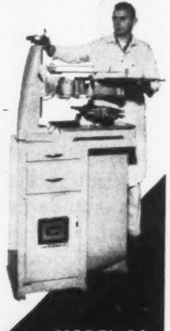
EPSCO will open a new subsidiary **MONITOR SYSTEMS INC.** in Fort Washington Industrial Park near Philadelphia, with *Harry H. Rosen* as general manager.

GENERAL CONTROLS CO. has formed a new Electronic Systems Div. in its Glendale-Burbank complex. The new organization will handle complete electronic systems; the existing Electronic Controls Div. will continue to produce only components.

GREEN *Pantograph Engravers*

ELIMINATE DELAYS!
Keep the work in your own plant.





PORTABLE 40-POUND BENCH-MODEL 106

Famous 2 or 3-dimensional engraver, successfully used by thousands, features 5 positive, accurate pantograph ratios. Versatile ball bearing spindle has three speeds up to 14,000 rpm; height of pantograph and position of cutter are continuously adjustable; one copy carrier (supplied) accepts all standard master type sizes.

The Model 106 has proven incomparable for speed and accuracy . . . yet reasonably priced.

Cutter grinders, rotary tables, master letters, compound slides, name plates and all required accessories. For complete information, write to

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 575 pounds — rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Micrometer adjustment for depth of cut
- Ball-bearing construction throughout — super-precision ball bearing spindle
- Spindle speeds up to 26,000 rpm for engraving or machining modern materials
- Ratios 2 to 1 to infinity master copy area 26" x 10"
- Vertical range over 10"

GREEN INSTRUMENT COMPANY, INC.
383 PUTNAM AVENUE, CAMBRIDGE 39, MASS.

CIRCLE 105 ON READER-SERVICE CARD

SCHLUMBERGER LTD. has acquired an 80% stock interest in **COMPUTER SYSTEMS, INC.** (formerly Mid-Century Instrumatic Corp.).

KENNETH E. HUGHES CO. has been named sales representative for Shockley Transistor Corp. (a subsidiary of Beckman Instruments) in the area of Metropolitan New York, New Jersey, and Eastern Pennsylvania.

people in the news

W. P. Baxter

W. M. O'Neill

I. I. Bezugloff

V. M. Meagher

W. R. Bleichner

H. C. Newton

STROMBERG-CARLSON announces appointment of *William P. Baxter* as supervisor, Military Marketing, and of *Walter M. O'Neill* as supervisor, Contract Administration.

ASSEMBLY PRODUCTS announces appointment of *Ivan I. Bezugloff, Jr.* as vice president and general manager of **METRONIX, INC.**, a wholly-owned subsidiary of Assembly Products.

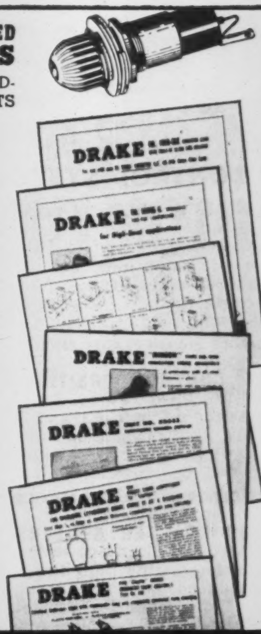
CONSOLIDATED ELECTRODYNAMICS announces appointment of *Vincent M. Meagher, Jr.*, as marketing manager for transducer products.

ROCKWELL MFG. CO. announces promotion of *W. Richard Bleichner* to advertising manager, Meter and Valve, and Petroleum and Industrial Divisions. *Hugh C. Newton* has been named assistant director of public relations.

FAIRCHILD CAMERA & INSTRUMENT CORP. announces that *Charles F. Kezer,* co-author of *I&CS* series on Electronic Circuitry, has been appointed program director for digital tape transport devices.

NORDEN DIVISION of United Aircraft Corp. announces appointment of *Samuel B. Sherwin* as manager of the **KETAY DEPARTMENT,** and assignment of the additional responsibilities of engineering manager to *Wladimir Reichel.*

SIMPSON OPTICAL MFG. CO. announces four top-level promotions: *Edward E. Bickel* has been appointed vice president, engineering; *William T. Strickland, Jr.* has been named vice president, manufacturing; *James E. Curtin* has become vice president, sales; and *Franklin A. Biber* is now secretary and controller.



SEND FOR THESE DETAILED DATA SHEETS
ON MINIATURE LAMPHOLDERS AND INDICATOR LIGHTS

- No. X3245 — Electronic Triggerswitch
- No. R115 — "Mineon" Indicator Light Assembly
- No. 101N-022 — Neon Glow Indicator Light Assembly
- No. H2005-IL — "Mini-space" 2-Pin Lampholder
- Series 1900 — 2-Pin Lampholders with Mounting Brackets
- "Tinylite" Midget Screw Lampholders
- No. 121 — "Tinylite" Midget Indicator Light Assemblies

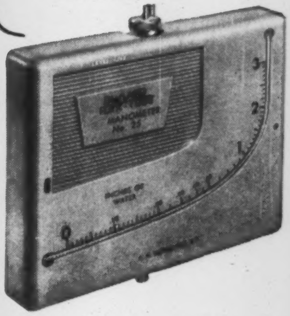
and also the Quick-Reference Catalog of the big DRAKE line.

DRAKE

DRAKE MANUFACTURING COMPANY
4624 N. OLCOTT AVENUE • CHICAGO 31, ILLINOIS

MINIATURE LIGHTING SPECIALISTS

CIRCLE 107 ON READER-SERVICE CARD



NEW **Dwyer** FLEX-TUBE Series 25

THE MANOMETER THAT

- COSTS HALF as much
- Is only HALF as BIG
- IS ACCURATE to 3%
- Does 4 NEEDED JOBS

and is practically indestructible!

Only 7⅜" wide, 5⅞" high and 1$\frac{3}{32}$" deep. Housing and tube of tough Tenite II plastic. Logarithmic indicating tube for accurate and easy reading. Two ranges: 0-3" and 0-7". Gages (1) static pressure, (2) draft, (3) filter resistance and (4) velocity from 0-7000 fpm. (with pitot tube).

A complete "package." Unit includes all necessary connector tubing and fittings, mounting screws, fluid, instructions.

Write for informative catalog page

F. W. DWYER MFG. CO.
P. O. BOX 373—S MICHIGAN CITY, INDIANA

CIRCLE 108 ON READER-SERVICE CARD

new literature

CONTROL SYSTEMS

CONTROL PANELS. 16-page Product Specification G-71-7 gives details of construction, dimensions, weights, instrument mounting, and accessories for six standard styles of instrument and control panels.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 214 ON READER-SERVICE CARD

TAPE CONTROL POSITIONING. 10-page brochure, Form LO-5902, describes the advantages and illustrates various applications of tape control positioning.—Jones & Lamson Machine Co., Springfield, Vt.

CIRCLE 215 ON READER-SERVICE CARD

MOTOR STARTER CENTERS. 4-page Bulletin 58-C discusses savings in initial costs, wiring, engineering time, and reduced maintenance costs that result from mounting starter centers in control panels.—Richardson Scale Co., Clifton, N. J.

CIRCLE 216 ON READER-SERVICE CARD

MINE FAN CONTROL. 2-page Bulletin 5902 explains "709" mine fan and circuit breaker monitoring and control system.—Femco, Inc., Irwin, Penna.

CIRCLE 217 ON READER-SERVICE CARD

MOTORS, GENERATORS, STARTERS

FHP MOTORS. 12-page catalog describes and illustrates the basic line of fractional-horsepower electric motors, blowers, and special products.—Redmond Co., Inc., Owosso, Mich.

CIRCLE 218 ON READER-SERVICE CARD

MOTOR CONTROLLERS. 4-page Bulletin 14B8750 describes oil-immersed squirrel cage motor controllers.—Allis-Chalmers Mfg. Co., P.O. Box 512, Milwaukee 1, Wis.

CIRCLE 219 ON READER-SERVICE CARD

ENGINE/GENERATOR UNIT. 12-page Catalog 15-MP-1 describes engine-driven generator units for standby power controlled for instantaneous start.—United States Motors Corp., 102 West 5th Ave., Oshkosh, Wis.

CIRCLE 220 ON READER-SERVICE CARD

VALVES

CHECK VALVES. 4-page Bulletin W-11 describes and specifies rubber-lined swing check valve Fig. 25-D.—Golden Anderson Valve Specialty Co., 1232 Ridge Ave., Pittsburgh 33, Pa.

CIRCLE 221 ON READER-SERVICE CARD

TEMPERATURE REGULATOR. 4-page Bulletin J-180 describes sliding-gate temperature regulator.—OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 222 ON READER-SERVICE CARD

BUTTERFLY VALVES. 8-page Bulletin 583 illustrates and tabulates wafer butterfly valves for 7 pressure groups.—W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.

CIRCLE 223 ON READER-SERVICE CARD

DIFFERENTIAL PRESSURE REGULATORS. 2-page Catalog Sheet Section IV describes two new differential pressure regulators for steam service, Fig. 1200, Type C, and Fig. 1210, Type C.—Atlas Valve Co., 280 South St., Newark, N. J.

CIRCLE 224 ON READER-SERVICE CARD

FLOW, TEMPERATURE

GAS FLOW PRIMARY ELEMENT. 4-page Bulletin 178 describes a mass-flow primary element for use with gases. Includes features and basic theory.—National Instrument Labs., Inc., 828 Evarts St., N. E., Washington 18, D. C.

CIRCLE 225 ON READER-SERVICE CARD

SIGHT FLOW INDICATORS. 2-page Catalog Data Unit 350 provides information on sizes, materials, pressure-temperature ratings and dimensional specifications of reflex and transparent sight flow indicators.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 226 ON READER-SERVICE CARD

TURBINE FLOWMETERS. 4-page Bulletin 1384 describes Type 20 turbine

UNIQUE DESIGN ROTARY SWITCH—
5-SECOND WAFER REPLACEMENT

No Unsoldering or Disassembling . . . No Wire Removing . . .
Simply Lift out Any Wafer & Replace Instantly . . .
Highly Reliable—Presently Supplied for Military Applications

Reduces to seconds maintenance which otherwise could take a full day or more, saving valuable time. New design obsoletes old switches.

Switches are available in sizes approx. 2" x 2", 3" x 3" and 4" x 4" with lengths to accommodate up to 36 wafers. Virtually unlimited choice of switch circuit configurations. All connections are to a single bank of receptacles and are conveniently accessible from one side of the aluminum housing. Contacts are silver, gold or rhodium plated on a copper base. Wafers can be made to include printed circuitry and components in addition to their normal switching function.

Switches may be manually, motor or solenoid operated for use in any rotary selector switch application. Manufactured under Tabet U. S. Patent No. 2,841,660. Other U. S. and foreign patents pending. Write for details today.

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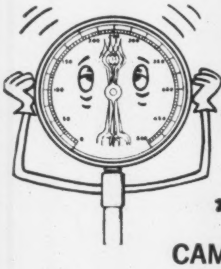
PRECISION PRODUCTS DIVISION
1725 Diversey Blvd., Chicago 14, Illinois

CIRCLE 109 ON READER-SERVICE CARD



SURE CURE for
HEADACHES DUE TO
PRESSURE GAUGE
JITTERS

CAMPBELL
MICRO BEAN

UNIVERSAL PULSATION DAMPENER

A Campbell Micro-Bean cures a headache ten times as fast as aspirin provided the headache is caused by a pressure gauge with a bad case of the jitters.
Rapidly becoming the standard pulsation dampener in many industries all over the world.

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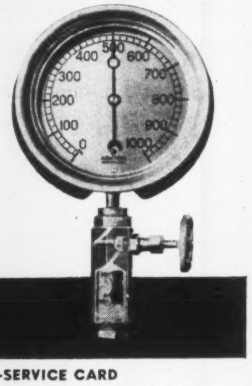


J. A. CAMPBELL COMPANY
645 East Wardlow Road
Long Beach 7, California

CIRCLE 110 ON READER-SERVICE CARD

flowmeters for measuring flow of jet fuel, gasoline, oil, water, acid, alkali, chemicals, and other liquids.—Cox Instruments Div., George L. Nankervis Co., 15300 Fullerton Ave., Detroit 27, Mich.

CIRCLE 227 ON READER-SERVICE CARD

CONVERSION CHARTS. 6-page cardboard folder presents conversion charts and technical data covering altitude pressure and temperature, centigrade to fahrenheit conversion factors, and several conversion factors for materials, heat, velocity, and vacuum, also dry bulb and temperature differential for relative humidity.—Conrad, Inc., Conrad Square, Holland, Mich.

CIRCLE 228 ON READER-SERVICE CARD

CRYOGENIC REFRIGERATORS. 6-page Folder F1262 gives complete data on four types of special cryogenic refrigerators.—Linde Co., Div. of Union Carbide Corp., 30 East 42nd St., New York 17, N. Y.

CIRCLE 229 ON READER-SERVICE CARD

PRESSURE, WEIGHT

PRESSURE SWITCHES. 36-page Design Handbook and Catalog PS-59-60 features complete line of Meletron pressure switches.—Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

CIRCLE 230 ON READER-SERVICE CARD

PRESSURE TRANSMITTERS. 4-page Bulletin R-1d provides descriptive information and application diagrams of Computran pressure transducers.—International Resistance Co., Computer Components Div., 401 N. Broad St., Phila. 8, Pa.

CIRCLE 231 ON READER-SERVICE CARD

ELECTRONIC WEIGHING with the Ametron Recorder is described in 12-page Brochure 1258-G338.—Streeter-Amet Co., Grayslake, Ill.

CIRCLE 232 ON READER-SERVICE CARD

TEST GAGES. 4-page Brochure 500SF describes line of solide-front pressure indicating and test gages.—Crosby Valve & Gage Co., Wrentham, Mass.

CIRCLE 233 ON READER-SERVICE CARD

COUNT, SPEED

COUNTERS. 4-page Condensed Catalog Form 227667 illustrates and describes mechanical and magnetic counters.—Veeder-Root Inc., Hartford 2, Conn.

CIRCLE 234 ON READER-SERVICE CARD

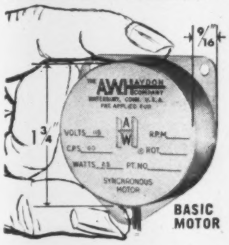
MINIATURE SPEED REDUCERS. 4-page Bulletin 97 describes Series 8 & 9 miniature fixed ratio speed reducers.—Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

CIRCLE 235 ON READER-SERVICE CARD

IMPULSE COUNTERS. 4-page bulletin illustrates and describes Sodeco panel-mounted predetermining electric impulse counters.—Landis & Gyr, Inc., 45 West 45th St. New York 36, N. Y.

CIRCLE 236 ON READER-SERVICE CARD

ANOTHER FIRST...



THE ONLY *Electro-Reliable*
A.C. TIMING MOTOR

Thinner... Quieter...
More Reliable... More Versatile

FINGER-THIN . . .
Only 9/16 Inches Short . . . Only 1¾ Inches in Diameter . . . very compact . . . reduces the size of your equipment.

WHISPER-QUIET . . .
Strictly an electrical motor . . . practically noiseless . . . no rattling of gears or ratchets.

HIGH TORQUE . . .
¼ oz. inch at the rotor with an instantaneous start and stop . . . requires only 2½ watts . . . can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY . . .
Longer life . . . no one-way gears or ratchets to fail . . . provides millions of operations without any trouble.

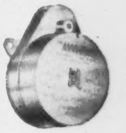
Send for Special Illustrated Bulletin AWH MO-806

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency:
60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch



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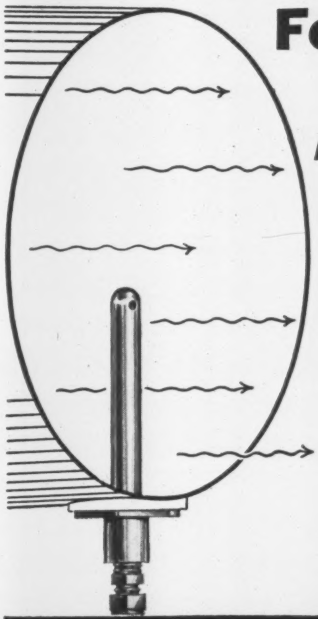
228 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

CIRCLE 111 ON READER-SERVICE CARD

Non-Cooled Thermocouple For High Velocity Gas Streams



At Temperatures Up To 3600°F.

This new thermocouple can be used without water or air cooling in the high velocity gas streams of jet engine afterburners and ramjet and rocket exhausts. It includes a cermet radiation shield and support tube. Conduction errors from cooling are eliminated and installation is simplified. Radiation losses are reduced about 60%. In a typical application this probe endured temperature cycling from 1500 to 3000°F. at a 1500 ft./sec. velocity for 20 hours with no failure. Temperature changes of 2000°F./sec. have created no adverse effects. Conductors used are Platinum 30% Rhodium/Platinum 6% Rhodium to 3000°F., and Iridium Rhodium/Iridium to 3600°F. Contact Thermo Electric for adaptation of this thermocouple to your needs.

Write For EDS-36-F

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.,
Brampton, Ont.

CIRCLE 112 ON READER-SERVICE CARD

THE OFFNER
ALL TRANSISTOR
DYNOGRAPH

TYPE
R

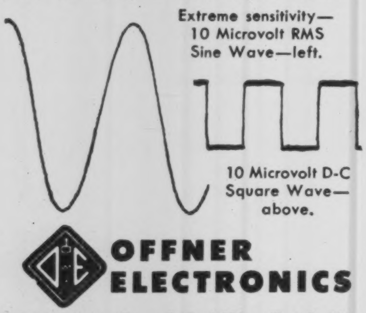
Models available: 1 to 19 channels, console, rack, and portable assemblies.

the most versatile . . . most sensitive direct-writing recorder available

Whatever your application for direct-writing oscillograph recording . . . investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Its features of superiority are *unmatched!*

- ✓ **High Sensitivity:** 1 microvolt d-c per mm
- ✓ **High Frequency Response:** 0-150 cps— ±10%
- ✓ **Large Linear Deflection:** over 6 cm—½% linearity
- ✓ **Wide Ambient Range:** −20° C to + 50° C
- ✓ **Versatile:** d-c, a-c, carrier, all with one set of amplifiers
- ✓ **Convenient:** Plug-in input couplers for all bridge balancing
- ✓ **Stable:** Drift—1 microvolt per hour at maximum sensitivity
- ✓ **Recording Media readily interchangeable:** Heat, Electric, Ink; Rectilinear, Curvilinear
- ✓ **Compact:** Eight channels in only 35" of rack space.

Write for full specs and complete details



Extreme sensitivity—10 Microvolt RMS Sine Wave—left.

10 Microvolt D-C Square Wave—above.

OFFNER ELECTRONICS
3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

CIRCLE 113 ON READER-SERVICE CARD

NEW LITERATURE

HAND TACHOMETERS. 4-page Catalog 61 contains detailed technical data on hand tachometers, Models 1600, 3200, 4800, 1HT and 3HT.—Jones Motrola Corp., 432 Fairfield Ave., Stamford, Conn.

CIRCLE 237 ON READER-SERVICE CARD

ELECTRONIC COUNTING. Catalog 5920 features complete line of high-speed electronic counting and control equipment.—Freed Transformer Co., Inc., 1746 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.

CIRCLE 238 ON READER-SERVICE CARD

WATER, GAS, OIL, SMOKE

WATER TESTING. 12-page Bulletin HSP-909 describes equipment and reagents for fast, on-the-spot water testing. Contains eight application tables.—Hagan Chemicals & Controls, Inc., Box 1346, Pittsburgh 30, Pa.

CIRCLE 239 ON READER-SERVICE CARD

GAS ANALYZER. 4-page System Specification Sheet 58-B631 describes and illustrates Magno-Therm Gas Analysis System.—Hays Corp., Michigan City, Ind.

CIRCLE 240 ON READER-SERVICE CARD

AIR AND GAS DRYERS. 4-page Bulletin D-108 describes 5 models of desiccant dryers with specs and dimensions.—Kemp of Baltimore, 405 East Oliver St., Baltimore 2, Maryland.

CIRCLE 241 ON READER-SERVICE CARD

FLUORINATED COMPOUNDS. 12-page brochure describes fluorinated waxes, oils and greases with chemical, physical and elecrical properties, toxicity, and solubility of the compounds. A fold-out contains the A.S.T.M. Standard viscosity-temperature charts for oils.—Halocarbon Products Corp., 82 Burlews Court, Hackensack, N. J.

CIRCLE 242 ON READER-SERVICE CARD

SMOKE DENSITY. 6-page Bulletin E-103-A describes smoke density indicators, Type S&C, and gives installation and operating instructions.—Reliance Instrument Mfg., Corp., 190 Glen Cove Ave., Glen Cove, L. I., N. Y.

CIRCLE 243 ON READER-SERVICE CARD

VIBRATION

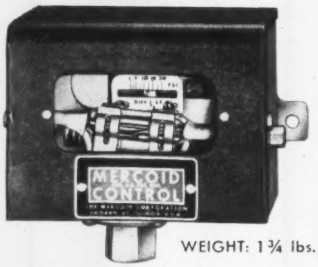
VIBRATION RECORDER. 2-page Bulletin K12A describes the Vibrograph, a small non-electric, hand-held instrument which makes a tape recording of machine vibration amplitude.—The Korfund Co., Inc., 48-15-35J—32nd Place, Long Island City 1, N. Y.

CIRCLE 244 ON READER-SERVICE CARD

VIBRATION TESTERS. 4-page Bulletin 3759 describes eight models of mechanical vibrator testers.—All American Tool & Mfg. Co., Not Inc., 8017 Lawndale Ave., Skokie, Ill.

CIRCLE 245 ON READER-SERVICE CARD

NEW
Small, Lightweight
MERCOID
PRESSURE
CONTROL
AP-153

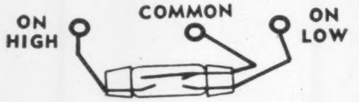


WEIGHT: 1¾ lbs.

FOR MEDIUMS NOT INJURIOUS TO STEEL OR SILVER SOLDER

CIRCUIT

SP-DT HERMETICALLY SEALED MERCURY SWITCH (4A. 115V., 2A. 230V.)



Provides any of following operations:

1. *Single Pole—Cut-in high (close on rise)*
2. *Single Pole—Cut-in low (open on rise)*
3. *Single Pole—Double Throw*

OPERATING RANGE

ADJUSTABLE OPERATING RANGE	SWITCH DIFFERENTIAL PSIG. With Pointer Set At LOW	HIGH
1 to 20 psig.	0.3	0.5

CONSTRUCTION

ADJUSTMENT: External
PRESSURE ELEMENT: Fairprene diaphragm
PRESSURE CONNECTION: ¼" I.P.S.
MOUNTING: Has two mounting ears (one on each side of control) or control may be pipe mounted by means of the ¼" I.P.S. bottom connection.
INTERNAL WIRING CONNECTIONS: 3 post terminal block.
CASE: NEMA 1—Heavy gauge steel, cadmium plated. Steel cover (with glass front) finished in charcoal-gray.

WRITE FOR BULLETIN 02

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

CIRCLE 114 ON READER-SERVICE CARD

VISCOSCITY SPECIFIC GRAVITY

VISCOSITY CONTROL. 2-page Data Sheet 091-B lists available 26 technical papers on viscosity determination and control.—Brookfield Engineering Labs., Stoughton, Mass.

CIRCLE 246 ON READER-SERVICE CARD

SPECIFIC GRAVITY INDICATOR. 2-page Bulletin 18S describes the company's indicators for continuous measurement of liquid specific gravity.—Schutte and Koerting Co., Dept. M-O, Cornwells Height, Bucks County, Penna.

CIRCLE 247 ON READER-SERVICE CARD

DATA HANDLING

COMPUTER APPLICATION. 6-page folder LGP-30 Application Report No. 11 describes how the Royal Precision LGP-30 electronic computer is determining the load flow in electrical networks of up to 100 busses and 270 lines.—Royal McBee Corp., Westchester Ave., Port Chester, N. Y.

CIRCLE 248 ON READER-SERVICE CARD

LINEAR ENCODER. 4-page Bulletin 318 describes and explains uses of linear encoder system.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 249 ON READER-SERVICE CARD

WIND TUNNEL COMPUTER. 16-page issue of "Data from Electrodata," April 1959, contains article on testing aircraft in Cooperative Wind Tunnel with Type 205 computer.—Burroughs Corp., Electrodata Div., 460 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 250 ON READER-SERVICE CARD

PAPER TAPE READER. 2-page data sheet describes paper tape reader Model PR-2 which is used with the G-15 general-purpose digital computer.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 251 ON READER-SERVICE CARD

ATOM REACTOR MONITORING. 8-page loose leaf folder describes applications of the RW-300 digital control computer in the nuclear field.—Thompson-Ramo-Wooldridge Products Co., P. O. Box 90067 Airport Station, Los Angeles 45, Calif.

CIRCLE 252 ON READER-SERVICE CARD

MULTIPLIER-DIVIDER. 2-page Data Sheet K5-M-PRE contains specifications, description, and application notes on multiplier-divider, Model K5-M, which is also described in issue No. 7 of "Lightning Empiricist."—George A. Philbrick Researches, Inc., 285 Columbus, Ave., Boston 16, Mass.

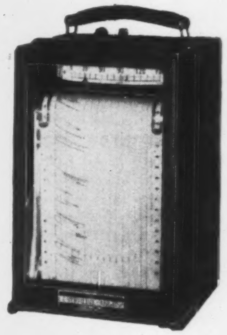
CIRCLE 253 ON READER-SERVICE CARD

DATA REDUCTION SYSTEM. 4-page bulletin contains specs, description, and application data on automatic PDM-to-digital computer format data reduction systems.—Epsco, Inc., Systems Div., 588 Commonwealth Ave., Boston, Mass.

CIRCLE 254 ON READER-SERVICE CARD

Do You Have
LOW VOLTAGE PROBLEMS?

Motors Hot? Fuses Blow? Frequent Burn-outs? Power Interruptions?



ESTERLINE-ANGUS Voltmeters
Can Help You Find
WHY and WHERE

AC: 0-50 to 0-800V.
DC: 0-2 to 0-800V.
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AC-DC: 0-1 to 0-800V.
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Product Representatives in Most Principal Cities

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CIRCLE 115 ON READER-SERVICE CARD

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LAMINATED & SOLID GLASS
FILTERS
INDUSTRIAL • SCIENTIFIC • PHOTOGRAPHIC

PRECISION OPTICS
WINDOWS • PRISMS • WEDGES

SPECIALIZED GLASS
VYCOR • PYREX • QUARTZ

PRECISION HOLE DRILLING
TOLERANCES TO .0001"

PRECISION EDGING SAWING, MACHINING
ON ALL TYPES OF GLASS & CERAMICS

PRECISION
OPTICAL MACHINING
METAL LENS MOUNTS • BARRELS • EYEPIECES

AUTOMATIC SCREW MACHINES TO 4" DIA. — ALSO HAND SCREW MACHINES — ENGLISH & METRIC THREADS OUR SPECIALTY.

Write for Filter Transmission Curve Catalog.

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TIFFEN OPTICAL CO.
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71 Jane St., Roslyn Heights, L.I., N.Y.

CIRCLE 116 ON READER-SERVICE CARD

MICO Precision Apparatus

NEW HEAVY DUTY 2 & 3 DIMENSIONAL ENGRAVER

FOR
Engraving Nameplates
Fine Routing Work
Profiling Small Objects
Making Small Dies and Molds

UHF COAXIAL WAVEMETERS

2-75 Centimeter Range

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CIRCLE 117 ON READER-SERVICE CARD

NEW
TENTH DEGREE (±0.1°)
PHASE STANDARD
OR SHIFTER

TYPE 714-A
Secondary
PHASE STANDARD

FEATURES:

- single audio frequency (400 cps standard) to produce known phase angles at output terminals
- use as either a phase shifter or phase standard
- phase angle stability over a variety of operating conditions
- one control — the phase angle selector with choice of 0°, 30°, 60°, 90°, 120°, 150° and 180° or others on special order

. . . and an extremely useful characteristic for systems application, due to unique design, the 714-A does not require an extremely precise input frequency.

No external calibrating or zeroing controls are required. As one of the output voltages is precisely in phase with the input, it may be used as a phase shifter or phase standard. It may be used to calibrate phase measuring or phase shifting equipment.

SPECIFICATIONS:

Input Signal: From external source
Input Frequency: 400 cps. ±5%. Other frequencies on special order
Input Voltage Amplitude: 0 to 10 v. rms.
Input Impedance: 100K (nominal)
Phase Angle Accuracy: ±0.1°
Output Voltage: 0 to 10 v. rms on each channel (unity gain)
Output Impedance: Low impedance on each channel (cathode-follower outputs)
Power Requirement: 105-125 v. rms, 60 cps, 35 W.

Write for full details
ACTON
LABORATORIES INC.
521 Main Street
Acton, Mass.
Subsidiary of Technology Instrument Corp

CIRCLE 118 ON READER-SERVICE CARD

NEW LITERATURE

OFFICE DATA HANDLING. 8-page Brochure RT-8952 entitled "How to Decentralize with Centralized Control" describes how a Synchro-Tape system can justify decentralization while retaining tight control for home office management.—Remington Rand, Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.
CIRCLE 255 ON READER-SERVICE CARD

DIGITAL READOUT. 2-page catalog sheet illustrates and describes Model SGS-101 digital readout.—I.D.E.A., Inc., Electronic Equipment Div., 7900 Pendleton Pike, Indianapolis 26, Ind.
CIRCLE 256 ON READER-SERVICE CARD

COMPUTER LANGUAGE TRANSLATOR. 6-page Bulletin B-59 provides descriptive information on computer language translator for process data systems.—Electronic Engineering Co. of California, 1601 East Chestnut Ave., Santa Ana, Calif.
CIRCLE 257 ON READER-SERVICE CARD

TESTING

ZENER DIODE TESTER. 2-page Catalog 115 details full specs and data on Zener diode tester.—Electronic Research Associates, Inc., 67 Factory Pl., Cedar Grove, N. J.
CIRCLE 258 ON READER-SERVICE CARD

DIELECTRIC TEST SET. 4-page Bulletin 22-5 describes a new test set for making step-voltage-current (or resistance) tests, voltage withstand, and breakdown tests on the insulation of electrical equipment.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.
CIRCLE 259 ON READER-SERVICE CARD

TEST RACK. 2-page Bulletin PIR 854-1 outlines advantages, uses, and properties of test rack 231X.—Electronic Associates, Inc., Long Branch, N. J.
CIRCLE 260 ON READER-SERVICE CARD

ENVIRONMENTAL TEST CHAMBERS. 12-page Catalog 59 covers line of environmental test chambers.—American Research Corp., Farmington, Conn.
CIRCLE 261 ON READER-SERVICE CARD

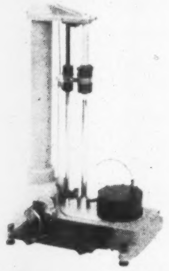
HYDRAULIC TEST CART. 2-page Bulletin 1373 describes a portable, self-contained hydraulic test cart for missile field test procedures.—George L. Nankervis Co., 15400 Fullerton Ave., Detroit 27, Mich.
CIRCLE 262 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

CARRIER AMPLIFIER. 2-page Bulletin 1612 describes carrier amplifier system CD-2, featuring double integration function.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.
CIRCLE 263 ON READER-SERVICE CARD

D-C AMPLIFIER. 2-page bulletin describes and specifies Model 114A dif-

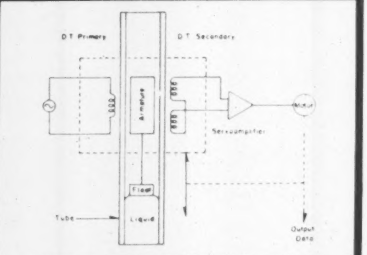
measuring pressure
or liquid level



Exactel
Servomanometers

offer servo-instrument utility in a liquid manometer

The Exactel Servomanometer design provides readout from mechanical counter and data shaft position, fast response, wide range and the highest accuracies that have been attained in commercial pressure and liquid level instruments. Stainless steel tubes are optional for high pressure uses. Analog Temperature Compensation, an exclusive development of Exactel, eliminates errors due to ambient temperature variation. Reliable calibration proving provisions are employed in instruments for use as calibration standards.



The basic principle...A differential transformer (DT) is continuously positioned by a servo to be electrically centered about a float containing magnetic material. A proportional shaft position in the servo transmission is then analogous to the position of the liquid column.

Applications for new Servomanometer techniques for general measuring and positioning, and 38 standard models, are described in Bulletin 500, available on request. Also Exactel offers full cooperation in custom design for special situations. Your inquiry is invited.

EXACTEL
INSTRUMENT
COMPANY

185 Evelyn Avenue
Mountain View, California
YOrkshire 8-5404

CIRCLE 119 ON READER-SERVICE CARD

ferential d-c amplifier.—Kin Tel Div. of Cohu Electronics, Inc., Box 623, San Diego 12, Calif.

CIRCLE 264 ON READER-SERVICE CARD

PHASE-SEQUENCE INDICATORS. 2-page Bulletin 1551 illustrates and specifies panel-mounting phase sequence indicators.—Opad Electric Co., 43 Walker St., N. Y. 13, N. Y.

CIRCLE 265 ON READER-SERVICE CARD

ELECTROMETER. 4-page Data Sheet EIL 33/3 describes Vibron electrometer for nuclear physics work manfactured by Electronic Instruments, Ltd., England.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

CIRCLE 266 ON READER-SERVICE CARD

D-C POWER SUPPLIES. 2-page leaflet illustrates and describes industrial high-voltage d-c power supplies.—NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.

CIRCLE 267 ON READER-SERVICE CARD

SWITCHES, RELAYS

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SWITCHES. 4-page catalog describes eight high-temperature thermal and seven waterproof switches.—Control Products, Inc., 306 Sussex St., Harrison, N. J.

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ROTARY SELECTOR SWITCHES. 4 2-page catalog sections illustrate and describe rotary selector switches with wafers which lift out.—Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago 14, Ill.

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POTENTIOMETERS

PRECISION POTENTIOMETERS. 20-page potentiometer-line catalog includes complete details of all production-model Helipot precision potentiometers, associated Duodial and Digidial turns-counting dials, Helidel delay lines, Helitrim trimming potentiometers, and lab model pots.—Helipot Div., of Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

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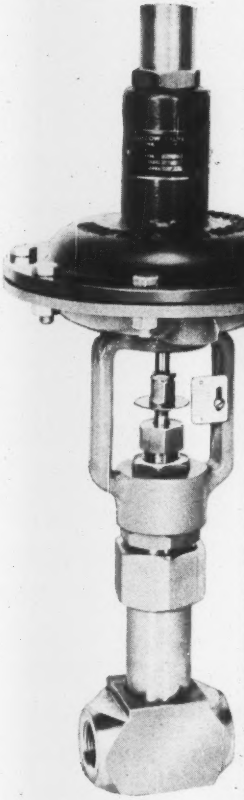

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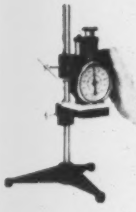

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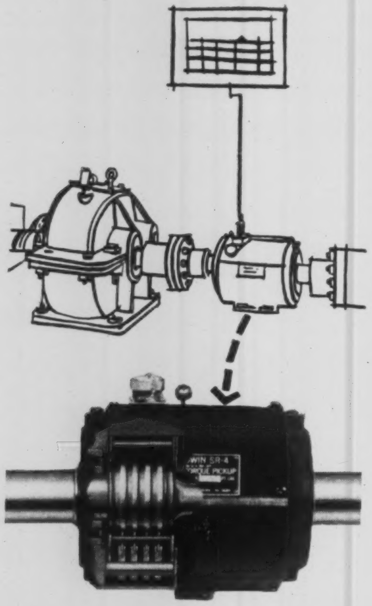

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SYSTEM BUILDING BLOCKS. 8-page Bulletin DAP- 9100 describes electrical, logical, and mechanical characteristics of eight transistorized building blocks.—Digital Equipment Corp., Maynard, Mass.

CIRCLE 275 ON READER-SERVICE CARD

ELECTRONIC COMPONENTS. 44-page Catalog 31 contains tabulated and illustrated information on capacitors, controls, switches and packaged electronic circuits.—Centralab, a Div. of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

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SUB-MIN RECTIFIERS. 2-page leaflet contains full specs and information on Series 80 copper oxide instrument rectifiers.—Conant Labs., Box 3997, Bethany Station, Lincoln 5, Neb.

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PUBLIC ADDRESS EQUIPMENT. 4-page Bulletin 258A describes public address equipment, including compound diffraction projectors, paging units, outdoor speaker systems, P. A. accessories, and microphones.—Electro-Voice, Inc., Buchanan, Mich.

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CRYSTAL OVEN. 4-page bulletin describes BM-1 constant-temperature crystal oven.—Federated Electronics, Inc., 139-14 Jamaica Ave., Jamaica 35, N. Y.

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CAPACITORS. 2-page Bulletin 214A illustrates and describes panel-mount trimmer capacitors.—JFD Electronics Corp., 1462-62 St., Brooklyn 4, N. Y.

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TRANSFORMER CORES. 2-page Bulletin 1-59 describes cores for current and potential transformers, magnetic amplifiers, and saturable reactors.—Magnetics Inc., Box 391, Butler, Pa.

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ATTENUATORS. 4-page Bulletin 44 describes Model 50 fixed coaxial attenuators.—Weinschel Engineering 10503 Metropolitan Ave., Kensington, Maryland.

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TERMINAL BLOCKS. 8-page booklet illustrates and describes controlled terminal blocks.—Marathon Special Products Corp., Erie, Penna.

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MATERIALS

SILICONES. 8-page Catalog CDS-129a highlights major silicone products and their uses.—General Electric Co., Silicone Products Dept., Waterford, N. Y.

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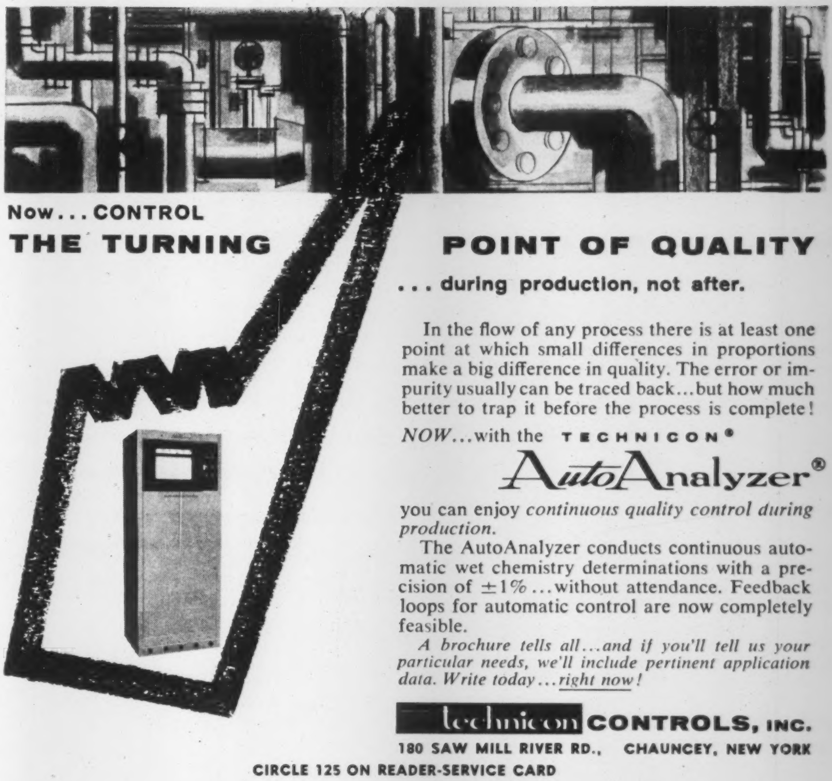

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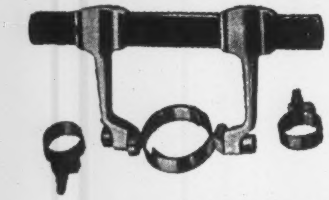

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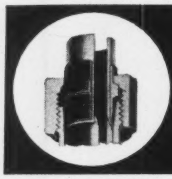

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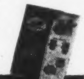

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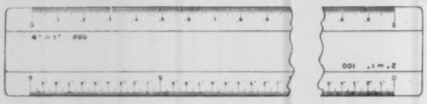

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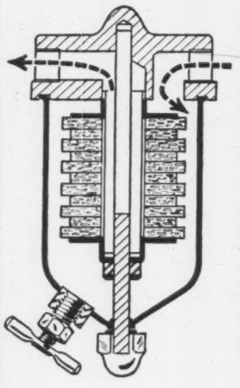

A new micronic air filter that provides extremely clean air in small volumes is now available from Air-Maze. The micron size retention efficiency is 95% for particles down to one micron; correspondingly higher efficiency for larger particles. The filter uses extended area felt discs for fine particle filtration. Manufactured for pipe sizes from 1/8" to 1½", designed to operate up to 150 psi.

The new Air-Maze micronic filter can be quickly disassembled. The felt discs are cleanable. And the housing has a petcock for removing any collected liquid.

For additional information write for Bulletin IAF-856.

AIR-MAZE CORPORATION
Dept. IC-7 • Cleveland 28, Ohio

CIRCLE 135 ON READER-SERVICE CARD

product index

The following is a handy reference to products (and their reader-service number) advertised or reported in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card at the right.

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

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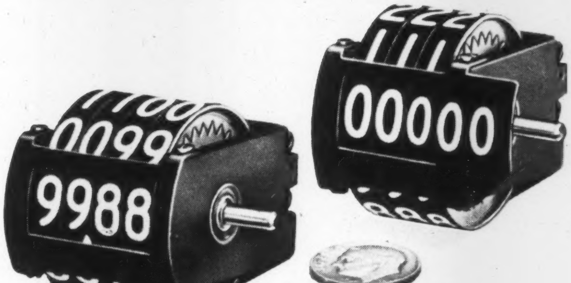

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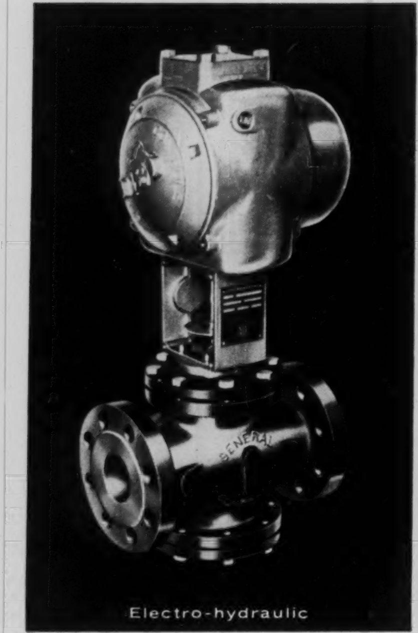
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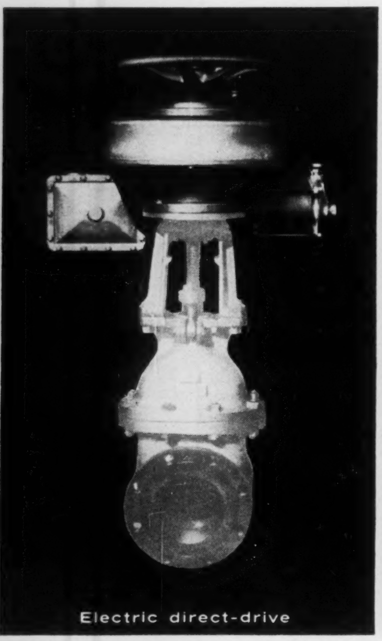
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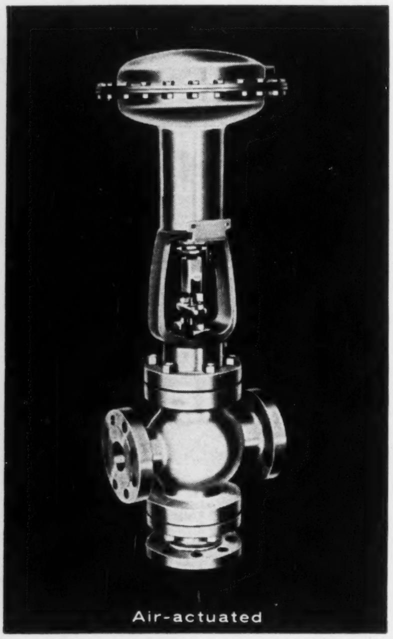
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